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NATIONAL DAM SAFETY PROGRAM. LOWER WARWICK RESERVOIR DAM (INVEN--ETC(U)
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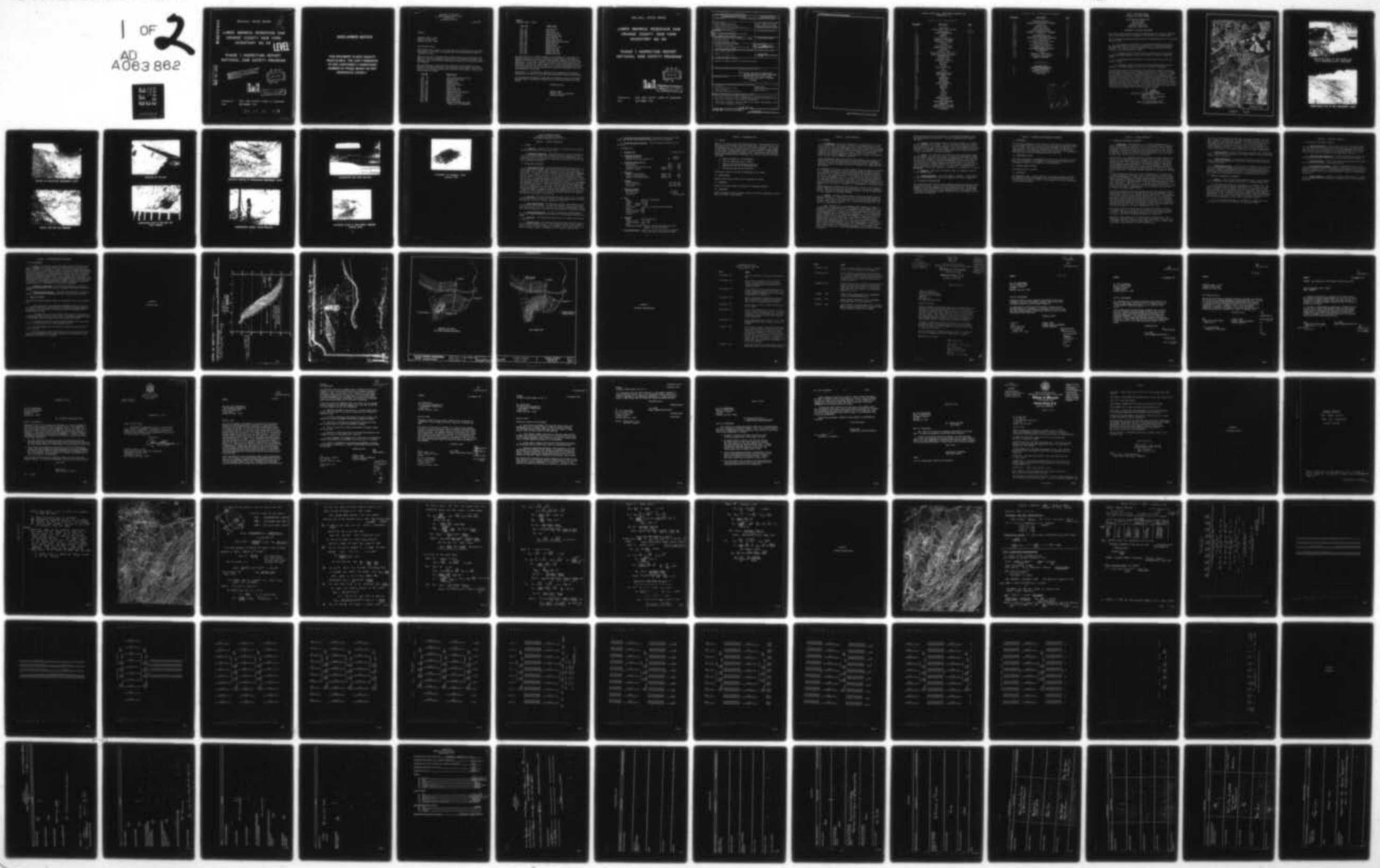

1 OF 2

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WALLKILL RIVER BASIN

(8) SC

LOWER WARWICK RESERVOIR DAM
ORANGE COUNTY NEW YORK
INVENTORY NO. 59

LEVEL II

406 957

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

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Date: SEPTEMBER 1978

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DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, NEW YORK
26 FEDERAL PLAZA
NEW YORK, NEW YORK 10007

2 OCT 1978

NANEN-F

Honorable Hugh L. Carey
Governor of New York
Albany, New York 12224

Dear Governor Carey:

The purpose of this letter is to inform you of a clarification of the guidelines used by this office in assessing dams under the National Program of Inspection of Dams.

Office of the Chief of Engineers has recently provided a clarification that dams with seriously inadequate spillways are to be assessed as unsafe, non-emergency, until more detailed studies prove otherwise or corrective measures are completed.

The following dams in your state have previously been assessed as having seriously inadequate spillways, with capability to pass safely only the percentage of the probable maximum flood as noted in each report. They are now to be assessed as unsafe:

I.D. NO.	NAME OF DAM
N.Y. 59	Lower Warwick Reservoir Dam
N.Y. 4	Salisbury Mills Dam
N.Y. 45	Amawalk Dam
N.Y. 418	Jamesville Dam
N.Y. 685	Colliersville Dam
N.Y. 6	Delta Dam
N.Y. 421	Oneida City Dam
N.Y. 39	Croton Falls Dam
N.Y. 509	Chadwick Dam (Plattenkill)
N.Y. 66	Boyds Corner Dam
N.Y. 397	Cranberry Lake Dam
N.Y. 708	Seneca Falls Dam
N.Y. 332	Lake Sebago Dam
N.Y. 338	Indian Brook Dam
N.Y. 33	Lower(S) Wiccopee Dam (Lower Hudson W.S. for Peekskill)

I.D. NO.	NAME OF DAM
N.Y. 49	Pocantico Dam
N.Y. 445	Attica Dam
N.Y. 658	Cork Center Dam
N.Y. 153	Jackson Creek Dam
N.Y. 172	Lake Algonquin Dam
N.Y. 318	Sixth Lake Dam
N.Y. 13	Butlet Storage Dam
N.Y. 90	Putnam Lake (Bog Brook Dam)
N.Y. 166	Pecks Lake Dam
N.Y. 674	Bradford Dam
N.Y. 75	Sturgeon Pool Dam
N.Y. 414	Skaneateles Dam
N.Y. 155	Indian Lake Dam
N.Y. 472	Newton Falls Dam
N.Y. 362	Buckhorn Lake Dam

The classification of "unsafe" applied to a dam because of a seriously inadequate spillway is not meant to connote the same degree of emergency as would be associated with an "unsafe" classification applied for a structural deficiency. It does mean, however, that based on an initial screening, and preliminary computations, there appears to be a serious deficiency in spillway capacity so that if a severe storm were to occur, overtopping and failure of the dam would take place, significantly increasing the hazard to loss of life downstream from the dam.

Consequently, it is advisable to implement the recommendations previously furnished in the reports for the above-mentioned dams as soon as practicable.

It is requested that owners of these dams be furnished a copy of this letter and that copies be permanently appended to all reports previously furnished to you.

Sincerely yours,

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

WALLKILL RIVER BASIN

LOWER WARWICK RESERVOIR DAM
ORANGE COUNTY NEW YORK
INVENTORY NO. 59

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

Prepared by: NEW YORK DISTRICT CORPS OF ENGINEERS
Date: SEPTEMBER 1978

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety
National Dam Safety Program
Visual Inspection
Hydrology, Structural Stability
Orange County
Lower Warwick Reservoir Dam
Wallkill River

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report provides information and analysis on the physical condition of the dam as of the report date. Information and analysis are based on visual inspection of the dam by the performing organization.

Lower Warwick Reservoir Dam was judged to be unsafe, non-emergency due to a seriously inadequate spillway.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

WALLKILL RIVER BASIN - LOWER WARWICK RESERVOIR DAM
INVENTORY NO. 59

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PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

LOWER WARWICK RESERVOIR DAM
NEW YORK STATE
ORANGE COUNTY
WALLKILL RIVER BASIN
INSPECTED 9 AUGUST 1978

ASSESSMENT OF GENERAL CONDITIONS

The visual inspection and evaluation of Warwick Dam and its spillway did not reveal conditions which are considered to be unsafe at the present time.

The following non-emergency measures should be implemented prior to the spring season of 1979:

1. The vegetation and debris on the downstream westerly portion of the embankment should be cleared and inspected by a licensed Professional Engineer. The extent of the root systems of large trees should be evaluated prior to indiscriminant cutting.

2. A drainage ditch to collect surface runoff should be constructed on the downstream embankment slope where runoff in presently eroding the slope.

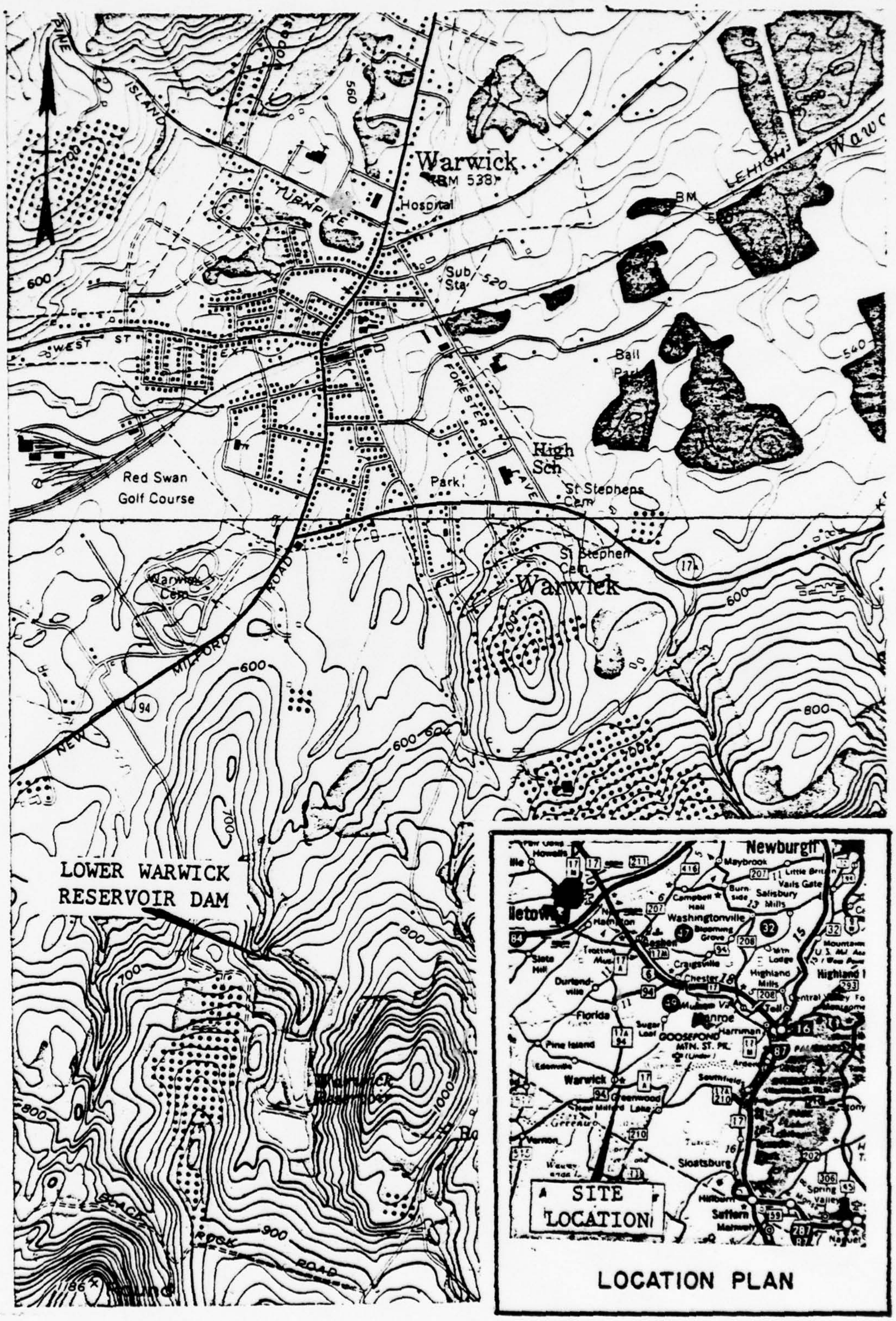
3. Toe drainage facility should be inspected and flow noted at frequent intervals.

4. A piezometer should be installed in the embankment and read periodically to evaluate changes in water level within the embankment.

The hydrologic analysis indicates that the spillway is capable of passing approximately 20 percent of the Probable Maximum Flood. Since the spillway is not capable of passing the Standard Project Flood, considered as one-half the Probable Maximum Flood, without overtopping the earth embankment and possibly causing failure, the spillway is therefore considered to be seriously inadequate in accordance with Corps of Engineers Screening Criteria. The hydrologic aspects of the dam should be further investigated and the Probable Maximum Flood computations refined. In the interim around the clock surveillance should be provided during periods of high flow, and a contingency plan initiated for implementation in the event of overtopping.

Approved by: Clark H Benn
CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

DATE: 27 September 1978

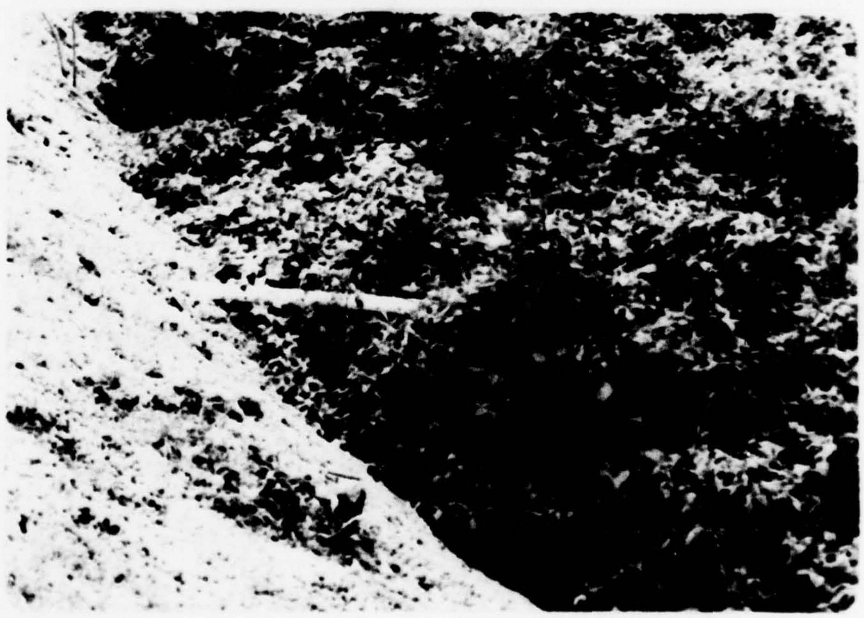


VICINITY PLAN

VIEW ALONG CREST OF DAM LOOKING EAST
(NOTE ABANDONED OUTLET STRUCTURE)

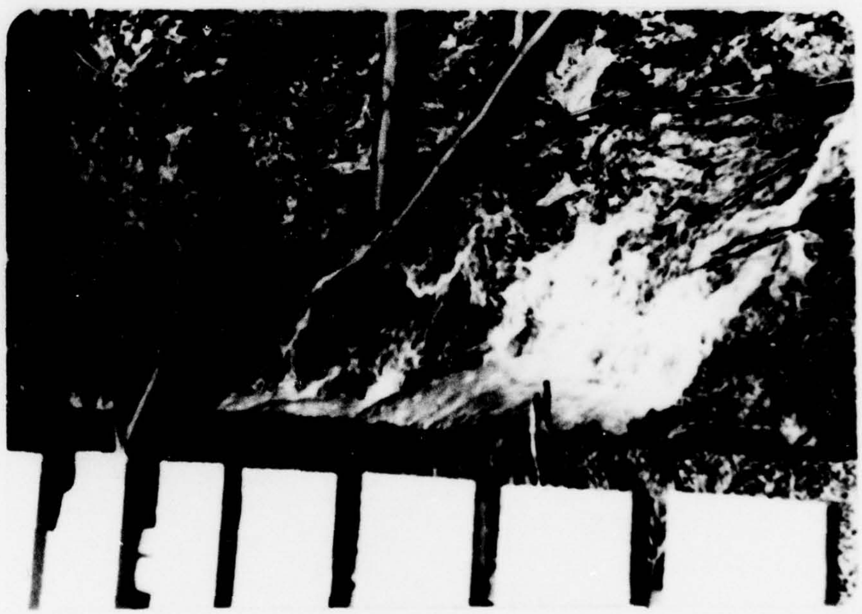
DOWNSTREAM FACE OF NEW EMBANKMENT SLOPE

EROSION ON DOWNSTREAM EMBANKMENT SLOPE



OUTLET PIPE FOR TOE DRAINAGE

OVERVIEW OF SPILLWAY



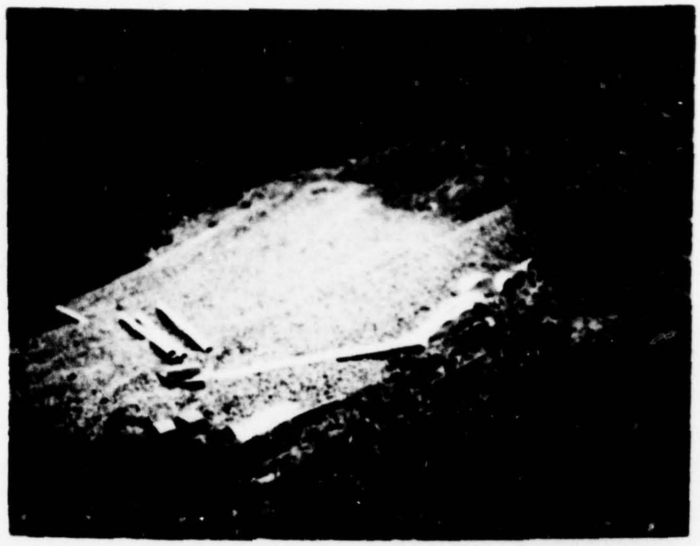
DOWNSTREAM FACE OF SPILLWAY AND ROCK CHANNEL

WESTERLY PORTION OF DOWNSTREAM EMBANKMENT SLOPE

DOWNSTREAM CHANNEL BELOW SPILLWAY

CLORINATION AND PUMP BUILDING

UPSTREAM SLOPE OF DAM DURING LOWERING
(SPRING 1978)



PLACEMENT OF DRAINAGE LAYER
(SPRING 1978)

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LOWER WARWICK RESERVOIR DAM I.D. NO. 59

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL:

a. Authority. Authority for this report is provided by the National Dam Inspection Act, Public Law 92-367, 1972.

b. Purpose of Inspection. The purpose of this report and inspection is to identify deficiencies and hazardous conditions; determine if they constitute hazards to human life or property; make recommendations for remedial measures where necessary and thus permit correction in a timely manner by non-Federal interests.

1.2 DESCRIPTION OF PROJECT:

a. Description of Dam. The Lower Warwick Reservoir Dam was built in approximately 1887 to supply water to the Village of Warwick, New York. It is the lowest of a system of three reservoirs used for the water supply of the Village. The dam is 210 feet in length; 185 feet being earth embankment possibly with a concrete core wall, and a 25 feet concrete gravity uncontrolled spillway. The dam crest is 3.3 feet above the spillway sill elevation of 679.8. The dam as originally constructed has a berm width of 12 feet and upstream and downstream slopes 1½ horizontal on 1 vertical. A 20 inch cast iron pipe serves as the outlet works for the reservoir. It runs through the embankment just west of center and terminates in the downstream channel at invert elevation 651.12. The outlet pipe is controlled by a manual gate valve at the downstream toe of the dam. The lower dam forms the most downstream impoundment of a pumped storage system, supplying water to the Village of Warwick. Water is pumped via an eight inch diameter cast iron pipe; an offshoot from the 20 inch outlet pipe; to the upper reservoir for eventual distribution, by gravity, to the village.

b. Location. The Lower Warwick Reservoir Dam, I.D. No. 59, is located approximately 1½ miles above the Village of Warwick, Orange County, New York. The latitude is 41°-14.1' and the longitude is 74°-21.7'.

c. Size Classification. The available storage is approximately 12 million gallons or 36.8 acre feet at normal pool elevation (crest of spillway) with a pool area of 3.4 acres. The crest of the dam is approximately 25 feet above the existing grade. Based upon the above the dam is classified as small.

d. Hazard Classification. The dam is classified as Hazard Category I based upon floodwave analysis and the proximity of downstream habitable development.

e. Ownership. The Lower Warwick Reservoir Dam is owned by the Village of Warwick.

f. Purpose of Dam. The Lower Warwick Reservoir Dam forms the lowest of three reservoirs supplying water to the Village of Warwick. Water released from the lower reservoir is pumped to the highest of the three reservoir systems for eventual release to consumers in the village via gravity flow.

g. Design and Construction History. The dam was constructed in 1887. Design data, plans, and construction information are not available.

h. Normal Operating Procedures. Formal operating procedures are not available.

1.3 PERTINENT DATA:

a. Drainage Area — 1.3 square miles

b. Discharge at Damsite

Maximum known flood		Unknown
Ungated spillway at maximum pool	386	C.F.S.

c. Elevations (above M.S.L.)

Top of dam		683.1	feet
Spillway crest		679.8	feet
Streambed at centerline of dam	Approx.	650.0	feet
Maximum tailwater	Approx.	652.0	feet

d. Reservoir

Length of maximum pool	Approx.	800	feet
Length of recreation pool	Approx.	700	feet
Length of flood control pool	Approx.	700	feet

e. Storage

Recreation pool	36.8 acre feet
Flood control pool	36.8 acre feet
Top of Dam	48.0 acre feet

f. Reservoir Surface

Recreation pool	3.4 acres
Spillway crest	3.4 acres
Top of dam	Not available

g. Dam

Type:	Earth Fill (compacted)
Length:	130 feet
Height:	Approx. 25 feet
Width:	Approx. 12 feet
Side Slopes:	1½H on IV (upstream and downstream)
Zoning:	None
Impervious Core:	None
Grout Curtain:	None
Cut-Off	?

h. Spillway

Type:	Broad crested weir
Length of weir:	24 feet
Crest elevation:	679.8 feet
Gates:	None
Downstream Channel:	Concrete spillway discharges into rock channel. (No stilling basin)

i. Regulating Outlets - There is a 20 inch outlet pipe at elevation 651.12 feet M.S.L. used for water supply.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN:

There is no original design information available. During December 1977 the New York District inspected the Lower Warwick Dam at the request of Mr. Carl Quackenbush, Supt. of Public Works for the Village of Warwick. The purpose of the inspection was to provide technical advice regarding seepage through the earth dam. Recommendations made by the New York District were implemented by the Village during the spring of 1978. Construction plans were prepared by Wehran Engineering of Middletown, New York and included the following items:

a. Immediate drawdown of the impoundment.

b. Clear the downstream slope of debris.

c. Construct an inclined drainage system with appropriate filter on the downstream face.

d. Line the upstream face with bentonite .

Construction plans are included as Appendix A of this report.

2.2 CONSTRUCTION:

Original construction records are not available for review.

2.3 OPERATION:

There are no formal records of operation or discharge available.

2.4 EVALUATION:

Detail information is not available, however, sufficient information is available for a Phase I investigation.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS:

a. Background. On 21 and 23 December 1977 representatives of the New York District, Corps of Engineers visited the Lower Warwick Reservoir Dam at the request of Mr. Carl Quackenbush, Supt. of Public Works for the Village of Warwick, to investigate thru seepage in the earth dam which had raised the concern of the village officials as to the integrity of the structure. The inspection was performed under the authority of Public Law 84-99 which authorizes the Corps of Engineers to lend technical assistance to non-federal public interests during emergency situations.

Visual observations at the time revealed thru seepage in the vicinity of the right abutment from approximately half-way down the downstream embankment slope to the base of the dam, seeping at several locations. Some piping was occurring at the seep locations and serious sloughing of the downstream face had occurred.

On 22 December 1977 the Supt. of Public Works, Village of Warwick was notified of a "potentially hazardous situation requiring immediate remedial action". On 23 December 1977 Governor Carey was notified of the distressed condition of the dam. On 6 January 1978 the State was advised to require the owner of the dam to take immediate action to: (a) drawdown the reservoir immediately (b) clear the downstream slope (c) construct an inclined drainage system on the downstream slope (d) provide a pipe weir at the drainage discharge (e) construct a stabilizing berm on the downstream slope (f) treat the upstream face with bentonite (g) install a piezometer on the embankment to monitor pore pressures.

Wehran Engineering of Middletown, New York, under contract to the Village of Warwick prepared a contract plan incorporating most of the above recommended actions. The work was completed during the spring of 1978 by Village personnel after approval of the plan by NYS DEC.

b. General. The Lower Warwick Reservoir Dam was inspected by Corps of Engineers personnel on 9 August 1978 as part of the National Dam Inspection Program. At the time of the inspection water was spilling approximately two to three inches above the spillway crest. The weather was sunny with a temperature of approximately 90°F.

c. Dam. The dam, built in approximately 1887, exhibited no signs of sloughing of the embankment slopes. The embankment and drainage system, constructed in the spring of 1978, as recommended by the New York District, was in excellent condition. A grass cover had been established on the new downstream embankment and the surface was well maintained. Surface drainage had eroded a shallow swale at the downstream embankment slope in the area of the eastern terminus of new construction. No evidence of seepage was noted on the downstream face and no water was evident in the toe drainage system. Numerous rock outcroppings were noted in the area, indicative of the earth section being founded on bedrock. It is questionable whether a concrete core wall, shown on an old drawing furnished by Mr. Quackenbush, actually exists. Areas of heavy bentonite concentrations were noted on the upstream slope, just below the water line. The abutment/embankment contact showed no evidence of distress.

Heavy growth on the entire western half of the downstream embankment slope prevented examination of this area. The above paragraph does not apply to this area.

d. Spillway. The spillway, located at the west abutment is a concrete gravity section 25 feet in width. Two to three inches of water was flowing over the spillway at the time of inspection. The concrete appeared to be in good condition with minor surface scaling. There is no evidence of structural cracking. The spillway is cut into bedrock and the west abutment contact is in rock. No evidence of distress was evident.

e. Outlet. A 20 inch cast iron outlet pipe extends through the embankment just west of the center of the dam. The outlet is controlled by a manual gate valve located in a valve pit at the downstream toe. The outlet control structure, located on the upstream embankment, and previously utilized to draw water from different levels, is not operable and is not utilized. The outlet pipe was extended upstream from the old control structure and presently draws water at elevation 659.6. The gate valve is maintained in a closed position except when drawdown of the reservoir is necessary. It is fully operational.

f. Reservoir. There was no noticeable signs of sloughing or erosion in the reservoir area.

g. Downstream Channel. The outlet channel is bedrock. A small amount of debris (tree limbs, etc.) was in the channel at the time of inspection.

3.2 EVALUATION OF OBSERVATIONS:

Visual observations did not reveal any conditions which would adversely affect the safety of the dam. However, the west downstream slope of the earth embankment could not be examined due to heavy growth and brush. The drainage collection system constructed on the downstream slope in the spring of 1978 is presently not passing any seepage, apparently due to the lining of the upstream face with bentonite.

SECTION 4 - OPERATION AND MAINTENANCE PROCEDURES

4.1 PROCEDURES:

The Lower Warwick Reservoir is the lowest of three reservoirs supplying water to the Village of Warwick. Water is normally discharged through the 20 inch cast iron outlet pipe, the gate valve at the downstream toe remaining in a closed position. The water is then pumped via an eight inch pipe to the upper reservoir for distribution to the village by gravity. The chlorination facilities are located just downstream from the lower dam.

4.2 MAINTENANCE OF DAM:

Heavy brush and growth on approximately one-half of the downstream slope made this area unaccessible. The remainder of the embankment and spillway are maintained in satisfactory condition by village personnel.

4.3 WARNING SYSTEM IN EFFECT:

No warning system is in effect.

4.4 EVALUATION:

Mr. Quackenbush, Supt. of Public Works for the Village of Warwick, informed the inspection team that the western half of the downstream slope will be cleared during the winter of 1978-79. The remainder of the dam is maintained in satisfactory condition.

SECTION 5: HYDROLOGY/HUDRAULIC

5.1 HYDROLOGIC EVALUATION OF FEATURES:

a. Design Data. Warwick Dam No. 1, is the most downstream dam of a series of three dams on a headwater tributary of Wawayanda Creek. Wawayanda Creek flows into Pochuck Creek, which is a tributary of the Wallkill River. The reservoirs formed by the dams are used for water supply for the village of Warwick. The dam is an earthen structure approximately 185 feet long and 25 feet high. The dam has a 24 foot concrete spillway cut out of rock and a 20 inch outlet pipe at its base for water supply.

Warwick Dam No. 1 was designed to function primarily as a water supply facility, not a flood detention structure. However, for the purpose of this investigation, the design features were analyzed with respect to their flood control potential. This potential was investigated through the application of the probable maximum flood (PMF) to the contributing basin. The PMF is that hypothetical flow induced by the most critical combination of precipitation, minimum infiltration losses, and concentration of run-off at a specific location, that is considered reasonably possible for a particular drainage area.

The contributing drainage area to the lower Warwick Dam is 1.3 square miles as shown on Appendix D. The main stream is relatively steep with an average slope of 350 feet per mile. Since this stream is typical of the fairly mountainous Appalachian Highlands, average Snyder parameters of 640 Cp = 400 and Ct = 2 were used for the determination of the unit hydrograph, the basic hydrologic working tool. Based on a Ct of 2, the lag time was developed as 2.7 hours. The lag time was increased by one hour to account for the time of travel through the system of three reservoirs for an estimated total lag time of 3.7 hours to the lowest reservoir site.

The probable maximum precipitation was developed through procedures in Hydrometeorological Report No. 33. The PMP index rainfall was determined to be 22 inches for a 24 hour storm duration over 200 square miles. The percentages of the index rainfall applied to other durations over the study basin were developed. Because of the critical nature of this storm, a fully saturated soil condition was assumed with minimum infiltration rates of 0.1 inch/hour. The peak discharge associated with the PMF as developed by the inclosed HEC I computer output is 1979 C.F.S. For purposes of this study, the standard project flood is taken as ½ the PMF or approximately 990 C.F.S.

The 24 foot spillway on the left bank of the dam was analyzed as a broad crested weir with a "C" coefficient of discharge of 2.65, using the formula $Q = CLH^{3/2}$. The maximum discharge capacity of the spillway with a head of 3.33 feet to the top of the dam was determined to be 386 C.F.S.

Based on a storage capacity of 12 million gallons, provided by Mr. Carl Quackenbush, the Warwick Supt. of Public Works, equivalent to 36.8 acre feet at spillway crest and a estimated surface area of 3.4 acres, a stage storage relationship was developed, as shown in Appendix D.

The lag time, Cp, drainage area, PMP index rain and percentages, loss rates and the reservoir storage versus discharge information was input into the HEC I program, "Flood Hydrograph Package". This program developed the unit hydrograph, the PMP rain data, applied the loss rates and developed the flood hydrograph. The PMF and a series of ratioed flood hydrographs were routed through the reservoir. An assumption of a full pool was made at the start of the routing. The technical computations are shown in Appendix D.

b. Experience Data. Warwick Dam has been operational since approximately 1890. As far as can be determined, it has safely passed all floods which have occurred since it was built.

c. Visual Observations. At the time of the on-site inspection, a few inches of water was flowing over the spillway, and there were no indications of any major problems.

d. Overtopping Potential. As far as can be determined, no actual storm event has had sufficient magnitude and duration to overtop the dam since it was built. However, the hypothetical probable maximum and standard project floods would cause overtopping of this dam. It is estimated that the spillway is capable of passing only 20 percent of the Probable Maximum Flood.

5.2 HYDRAULIC EVALUATION OF FLOODWAVE:

a. General. Since the lower Warwick Reservoir Dam is an earth embankment a condition of total failure was utilized in floodwave computations.

b. The downstream channel was investigated on 23 December 1977. The resulting floowave analysis employed approximations as to stream cross-sections. The first critical location in the event of a dam failure is 3600 feet downstream from the dam, where there is a residential home development. At this location the resulting floodwave would overtop the stream banks by approximately 4 feet. At the most downstream location (8000 feet downstream from the dam, in the center of the village of Warwick) the resulting floodwave would be approximately one foot above stream bank elevation.

c. It is considered that there is a potential for damage and loss of life caused by a failure of the dam and the resulting floodwave.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY:

a. Visual Observations. Visual inspection of the lower Warwick Reservoir Dam did not reveal any areas which would represent a potential hazard due to instability. The western half of the earth embankment could not be inspected due to heavy brush growth on the downstream slope. The spillway is cut in rock and did not exhibit any serious signs of distress.

b. Design and Construction Data. No design computations or other data regarding the structural stability of the dam or spillway are available.

c. Operating Records. No major operational problems which would affect the stability of the dam or spillway were reported.

d. Post Construction Changes. Repairs on the western portion of the downstream embankment slope were completed in the spring of 1978. The recently placed toe drainage facility is not passing water, indicative that the impervious blanket placed on the upstream slope in this area is functioning as anticipated.

e. Seismic Stability. The dam is located in Seismic Zone No. 1, therefore no seismic analysis are warranted in accordance with Corps of Engineers guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT:

a. Safety. The portion of the Lower Warwick Reservoir Dam, which was able to be inspected, did not exhibit any problems which would require an unsafe assessment. No evidence of seepage or unusual settlement was observed at the time of inspection, however, due to the presence of heavy brush growth, the entire western half of the embankment was neither observed nor inspected. Preliminary hydrologic evaluations performed indicate that the dam would be topped by the Standard Project Flood. It is estimated that the spillway is capable of passing 20 percent of the Probable Maximum Flood. Therefore, since the spillway is not capable of passing the Standard Project Flood, considered as one-half of the Probable Maximum Flood, without overtopping the dam and causing failure, it is considered to be seriously inadequate.

b. Adequacy of Information. No reliable information was available regarding the dam section. This report is primarily based upon visual observations.

c. Additional Investigations. Additional investigations to assess the safety of that portion of the dam and spillway observed are not necessary.

7.2 REMEDIAL MEASURES:

The following remedial measures should be accomplished prior to the spring of 1979:

1. The western half of the downstream embankment should be cleared of all vegetation and debris and inspected by a licensed professional engineer. The extent of the root system of large trees should be evaluated prior to indiscriminant cutting.

2. A drainage ditch to collect surface runoff should be constructed on the downstream slope in the area where runoff is eroding the downstream slope. A crushed gravel ditch lined with filter cloth should be provided.

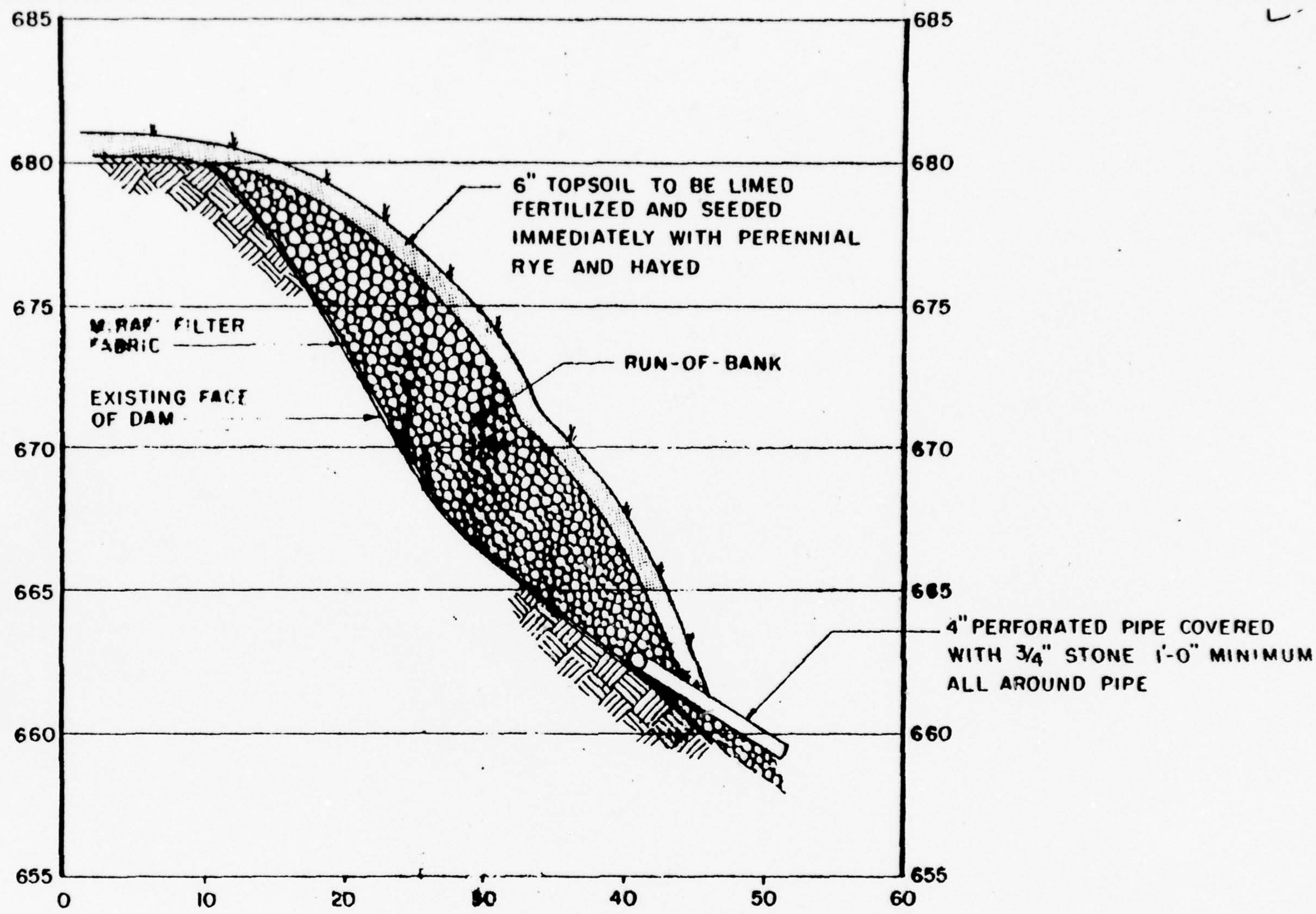
3. A piezometer should be installed in the embankment and read periodically to evaluate water levels in the embankment soils.

4. The toe drainage facilities should be inspected and flow noted at weekly intervals.

5. During periods of high flows around-the-clock surveillance of the dam should be provided and a contigency plan should be initiated for implementation in the event of overtopping.

APPENDIX A

AVAILABLE PLANS



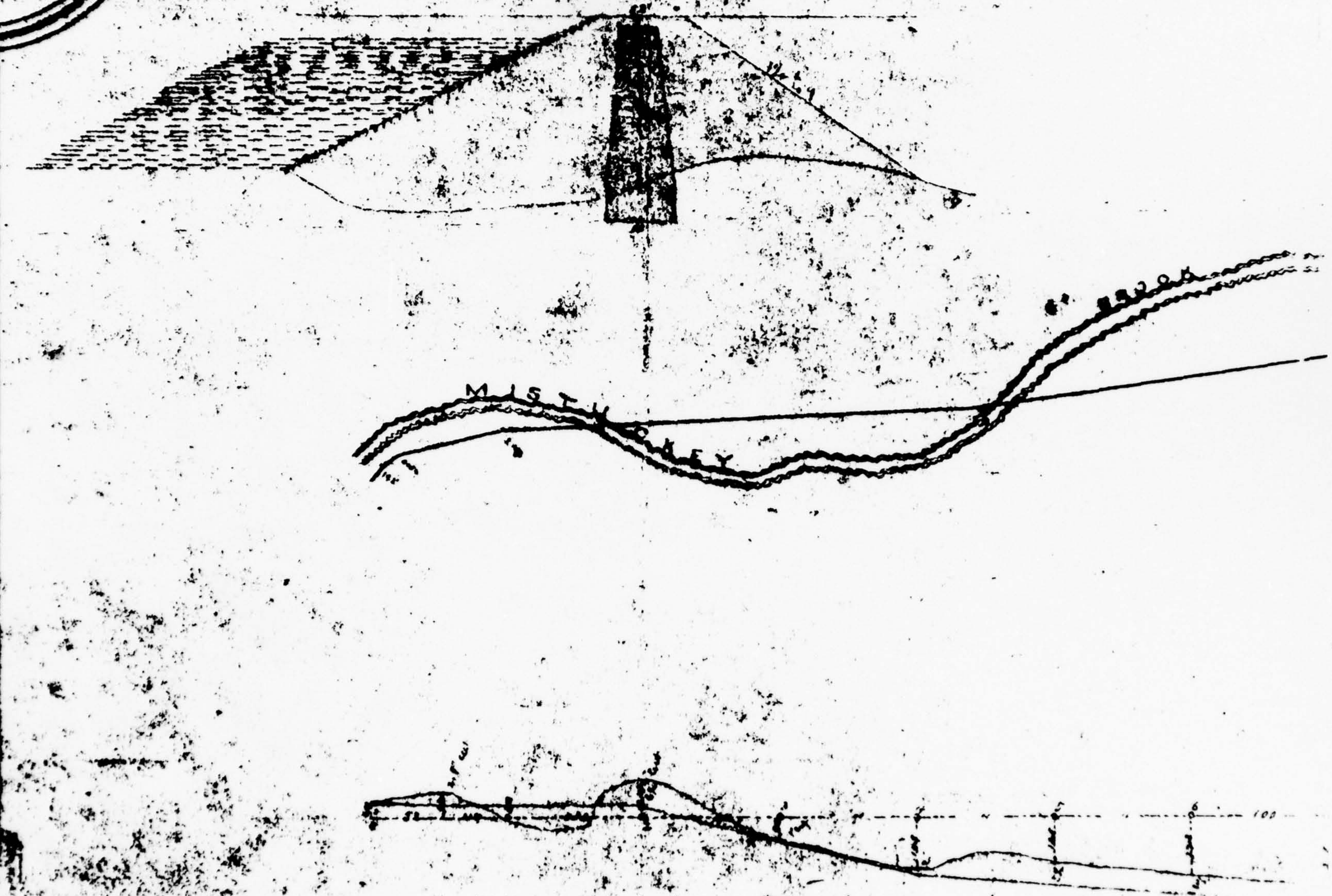
SECTION A-A

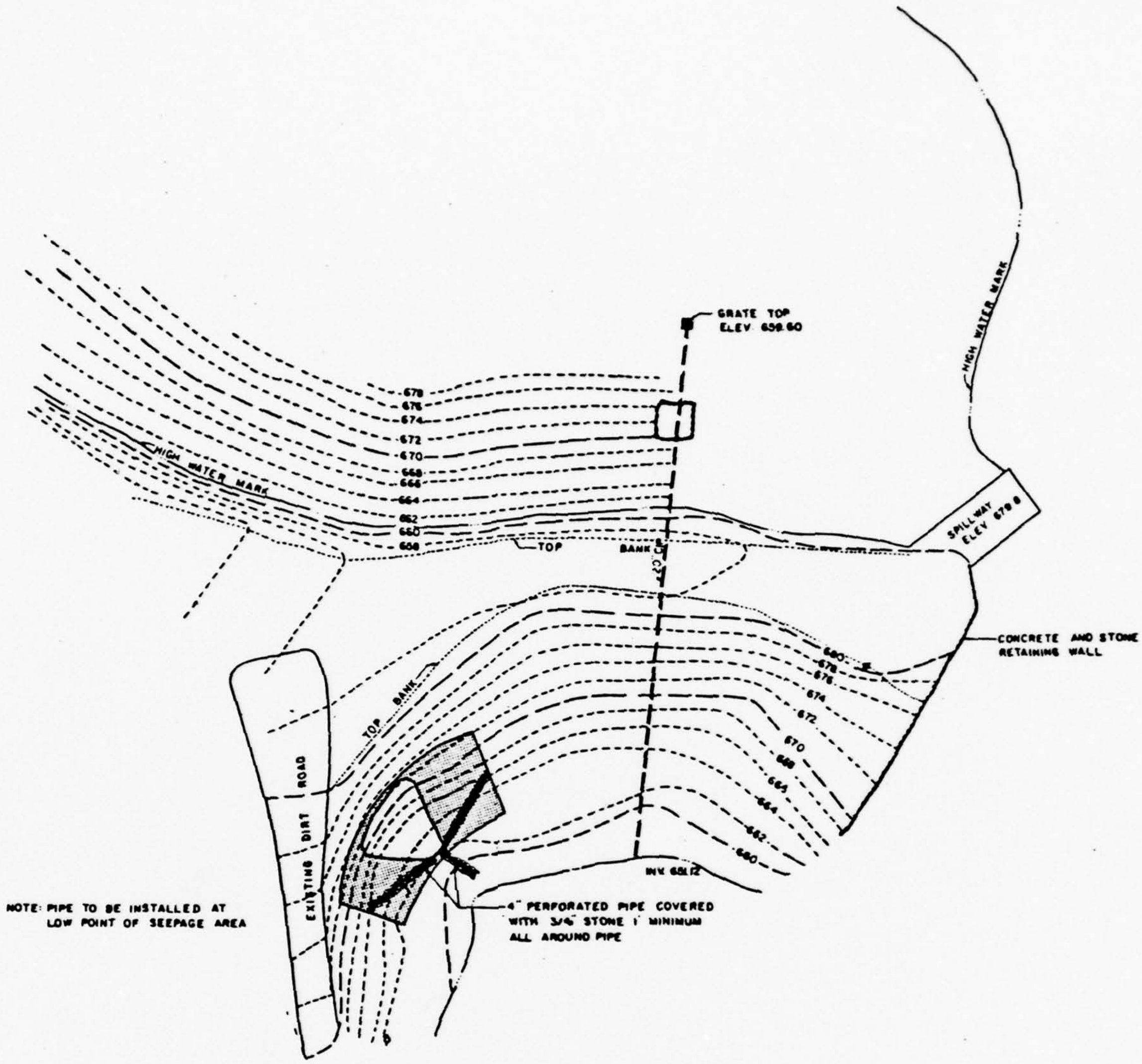
SCALE: 1" = 10' HORIZONTAL
1" = 5' VERTICAL

Remedial Slope Stabilization
& Drainage (Spring '78)

Sc...	RICHARD A. PELUSO, P.E.		VILLAGE OF WARV

CROSS SECTION OF DAM AT STATION A

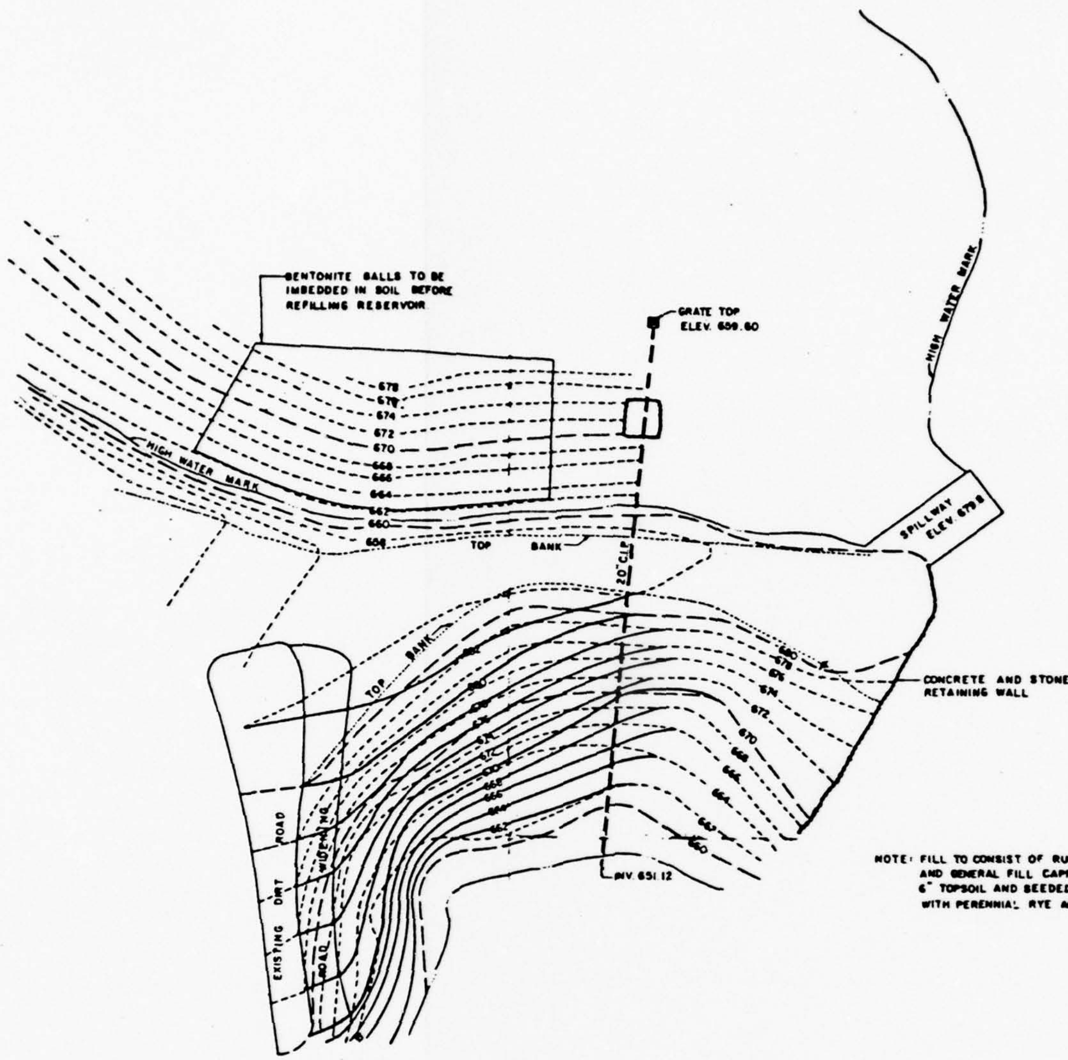




TOPOGRAPHY OF DAM NO. 1

WITH CONTROL MEASURES FOR SEEPAGE

WEHRAN ENGINEERING CONSULTING ENGINEERS	Drawn by: S.W.W. Checked by: R.A.P. Date: 5/2/78	Scale: 1" = 20'	RICHARD A. PELUSO, PE N.Y. Lic. No. 48021 Date:



NOTE: FILL TO CONSIST OF RUN-OF-BANK AND GENERAL FILL CAPPED WITH 6" TOPSOIL AND SEEDED IMMEDIATELY WITH PERENNIAL RYE AND HAYED

FINAL GRADING PLAN

5/2/7_ Date	VILLAGE OF WARWICK WARWICK, NEW YORK	REMEDIAL MEASURES RESERVOIR NO. 1 DAM SEEPAGE	Sheet 1	of 1
			Project No. 01214032	

APPENDIX B

PERTINENT CORRESPONDENCE

CHRONOLOGY OF EVENTS
VILLAGE OF WARWICK, NEW YORK
DAM (I.D. No. 59)

DATE	EVENT
21 December 1977	Physical inspection of dam by John Dioguardi, NAN
22 December 1977	Letter from J.A. Weiss to Supt. of Public Works, Village of Warwick alerting him to "potentially hazardous situation requiring immediate action."
23 December 1977	Letter from Col. Benn to Governor Carey indicating "sufficient evidence of distress as to warrant immediate remedial action to preclude to possibility of failure."
23 December 1977	Physical inspection by Hydraulics Section of dam to determine the effects of a possible dam failure on the downstream population .
23 December 1977	Letter from J.A. Weiss to NAD alerting them to all the above.
30 December 1977	Letter from George Koch, N.Y.S. DEC, to Supt. of Public Works instructing him to: (a) Lower reservoir, (b) cut and remove trees and brush on downstream slope of dam for more complete visual observation.
30 December 1977	Letter from Secretary to Governor to Col. Benn acknowledging Col. Benn's letter of 23 Dec 77 (above).
6 January 1978	Letter from Col. Benn to George Koch advising him of Warwick problem and calling for various "immediate actions" to be taken to include: (a) immediate drawdown, (b) clearing of downstream slope, (c) construction of inclined drain system, (d) provide pipe weir, (e) construct stabilizing berm, (f) bentonite treatment of upstream fall, (g) installation of piezometer on downstream embankment.
12 January 1978	Internal DF from Chief, Design Branch evaluating downstream effects should total failure occur.

DATE	EVENT
23 January 1978	Letter to George Koch from J.A. Weiss advising him of results of hydraulics investigation.
14 February 1978	Telecon between John Dioguardi and George Koch, re: Village of Warwick Dam basically indicating that brush and debris had been removed from downstream slope but that water level had not been lowered by owners.
21 February 1978	Letter from J.A. Weiss to George Koch reiterating potential danger this dam poses to downstream inhabitants and calling again for lowering the water level and use by N.Y.S. of its enforcement authority to do so.
3 March 1978	Letter from Mr. George Koch to Mr. Quackenbush relative to dewatering procedures.
22 March 1978	Letter from Mr. George Koch to Mr. Quackenbush giving permission to drain reservoir.
27 March 1978	Letter from Mr. Carl Quackenbush, Supt. of Public Works, Village of Warwick to Mr. George Koch, NYS DEC giving status of reservoir lowering.

OFFICE OF THE CORPORATION
MEETINGS HELD SECOND MONDAY OF EACH MONTH

Village of Warwick
77 MAIN STREET 10990
Orange County, N. Y.
AREA CODE 914 986–2031

November 18, 1977

Daniel G. Parrillo:
North Atlantic Division
U.S. Army Corp. Engineers
NADEN-TG
90 Church St.
New York, New York 10007

Dear Mr. Parrillo:

After my telephone conversation with you on November 15th, I was speaking with my water plant operator about our conversation. He asked if I had mentioned to you the leak we have in the dam of the lowest reservoir, which we have been aware of for the past couple of years. Why I didn't think to tell you of this during our conversation I can't explain. We have been involved in many different projects for the past few months and things have been somewhat hectic. I guess I was not thinking straight.

I thought I would make you aware of this by letter, in hopes you might be able to arrange for one of your personnel to look at this and inform us if there might be a temporary correction we might be able to make.

I am not sure which I.D number applies to this dam. Following are our I.D. numbers you gave me: #0059,#0062 and #0063.

Thanking you in advance.

Very truly yours,

Carl Quackenbush

Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

Engr Div
JD

DIOGUARDI/dms/9111

NANEN-F

2 2 DEC 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

Dear Mr. Quackenbush:

Reference is made to your telephone conversation with Mr. John Dioguardi of my staff concerning a reported "leak in the dam of the lowest reservoir in the Village of Warwick."

An inspection of the dam under the authority of Public Law 99 has been scheduled for Wednesday, 21 December 1977 in your office. Any plans and/or design or construction records you may have available would be most beneficial.

Sincerely yours,

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

cc:w/incl:
Caspe
Lawska (Oper Div)
Mr. George Koch
50 Wolf Road
Albany, N.Y. 12233

CASPE/NANEN-F
FAFINSKI/NANEN
WEISS/NANEN
~~PAO/NANPA~~
EA/NANEX
DDE/CW
DE

JD
DIOGUARDI/dms/9111

NANEN-F

22 December 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

Dear Mr. Quackenbush:

On 21 December 1977 an on-site inspection of the lowest of the three (3) earth dams, inventory I.D. No. 59, Hazard Category 2, in the Village of Warwick, Orange Co., N.Y. was made at your request.

Visual observations revealed through seepage in the vicinity of the right abutment from approximately half-way down the slope which has caused considerable sloughing and softening of the downstream embankment. We consider this to be a potentially hazardous situation requiring immediate action to alleviate the condition. A copy of the above has been forwarded to theGGovernor of the State and the State regulating agency charged with dam safety.

Sincerely yours,

CASPE/NANEN-F

J.A. WEISS
Chief, Engineering Division

FAFINSKI/NANEN

WEISS/NANEN

CASPE/ijo/9110

23 DEC 1977

NANEN-F

Honorable Hugh L. Carey
Covernor of New York
Albany, New York 12224

Dear Governor Carey:

New York District Corps of Engineers inspection performed on 21 December 1977 of dam in the Village of Warwick, Orange County, New York (I.D. No. 59, Hazard Category 2) revealed the dam to have sufficient evidence of distress as to warrant immediate remedial action to preclude the possibility of failure. Pursuant to this a joint Corps-State inspection to determine the effects of a possible dam failure on the downstream population is scheduled for Friday, 23 December 1977.

Sincerely yours,

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

Incl
Letter Supt Public Works,
Warwick, N.Y.

cc: G. Koch, NYS DEC
Supervisor of Dam Safety

FAFINSKI/NANEN

WEISS/NANEN

PAO

AA

DDE

DE

CASPE/dms/9111

NANEN-F 23 December 1977

SUBJECT: Dam Inspection in the Village of Warwick, New York

Division Engineer, North Atlantic
ATTN: NADEN-TF

1. Inspection performed on 21 December 1977 by NAN of dam in the Village of Warwick, Orange County, N.Y. (I.D. No. 59, Hazard Category II) revealed the dam to have sufficient evidence of distress as to warrant immediate remedial action to preclude the possibility of failure.

2. Inclosed is correspondence transmitted to Village officials relative to the above. The Governor's Office and State Regulating Authority responsible for dam safety have been advised. Consequently, a joint NAN-STATE inspection is scheduled for Friday, 23 December 1977 to evaluate the effects of a possible dam failure on the downstream population.

Incl
Letter Supt. Public Works
Warwick, N.Y. 22 DEC 77

J.A. WEISS
Chief, Engineering Division

CC w/incl: Rosen
C, Design Br

FAFINSKI/NANEN
WEISS/NANEN

December 30, 1977

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main St.
Warwick, NY 10990

RE: Dam #397, Lower Hudson Basin

Dear Mr. Quackenbush:

Reference is made to the inspections of December 21, 1977 and December 23, 1977 of the lower earth dam in the Village of Warwick. The inspections were made by the NY District Corps of Engineers and New York State. Reference is also made to the letter of December 22, 1977 from the Corps of Engineers. This letter indicates that the seepage has caused considerable sloughing and softening of the downstream embankment. In order to remove the hazard to the downstream residents, the following remedial work should be performed immediately:

1. The water surface of the reservoir should be lowered below the seep. The seep appears about 6 feet below the existing water surface, therefore, the water surface should be lowered about 8 feet by opening the drain pipe.

2. At the time of the inspections, the trees and brush on the downstream slope of the dam prevented a thorough inspection of the earth embankment. The trees and brush along the entire downstream earth embankment should be cut and removed. This will enable us to observe the seepage area as well as the rest of the embankment.

When you have lowered the water surface and removed the trees and brush, please inform me. If you have any questions, please call at (518) 457-1216.

Yours truly,

George Koch
Supv. Dam Safety Section

cc: J. Caspe

~~1. Col Benn~~
2. C/Engineering

STATE OF NEW YORK
EXECUTIVE CHAMBER
ALBANY 12224

ROBERT J. MORGADO
SECRETARY TO THE GOVERNOR

December 30, 1977

Dear Colonel Benn:

On behalf of Governor Carey, I acknowledge your letter of December 23 advising on a joint Corps-State inspection to determine effects of a possible dam failure on the downstream population of the Village of Warwick.

Sincerely,

Robert J. Morgado

Colonel Clark H. Benn
New York District, Corps of Engineers
Department of the Army
26 Federal Plaza
New York, New York 10007

DIOGUARDI/dms/9110

NANEN-F

6 JAN 1978

New York State Department of
Environmental Conservation
ATTN: Mr. George Koch
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

On 21 and 23 December 1977 members of my staff met with Village of Warwick, New York representatives regarding a Village request to investigate and evaluate an earth dam which was reportedly leaking at the base of the dam. As a result of these field inspections, it was determined that one of three earth dams forming part of a pumped storage water supply project for the Village was in fact experiencing through seepage in the vicinity of the right abutment. The dam, the lowest in both elevation and height of the three is an arched earth dam approximately 25 ft. high, 150 ft. long empounding approximately (12) million gallons of water. It has a 20-25 ft. wide uncontrolled overflow spillway at the left abutment at an elevation of approximately 5 ft. below the top of dam and a 20"ϕ blow-off pipe extending through and at the base of the dam controlled by a sluice gate on the downstream side. Operational procedures for the three dam system call for pumping of water from this lowest reservoir to the highest from which point the water would flow by gravity to a chlorination plant and subsequently for distribution into the water supply system of the Village.

Visual observations by field inspection teams revealed through seepage in the vicinity of the right abutment from approximately half-way down the dam embankment slope of the downstream face to the base of the dam seeping at several locations. Although flow measurements could not be made due to the fact that no quantitative instrumentation

was available, this type of seepage posess a definite threat to the integrity of the structure which requires that immediate remedial actions be taken. In addition, a field inspection of downstream development revealed that the first of a row of one-family houses was only approximately 600 ft downstream with the Village's main population located further downstream. An evaluation of downstream impact should dam failure occur is presently being made.

In order to remove the immediate threat and insure that the seepage forces created by this through seepage do not cause dam failure the following immediate actions are recommended:

a. Immediate drawdown of the reservoir. During drawdown observations should be made at the seeps to determine their relation to reservoir stage.

b. The entire downstream slope should be cleared of debris and inspected in order to determine if additional seeps are present.

c. Construct an inclined drain system with appropriate filter and collector pipes to collect and channelize seepage.

d. Provide a pipe weir to measure and monitor discharge through the drain pipes.

e. Construct a stabilizing berm on the downstream embankment with a minimum slope of 2½ horizontal and 1 vertical.

f. After drawdown, the upstream face of dam should be examined and treated with bentonite in an attempt to seal the seep at its source.

g. Install a piezometer on the downstream embankment to measure pore pressure fluctuations as a means of determining the effectiveness of the drain.

Sincerely yours,

CASPE/NANEN-F

CLARK H. BENN
Colonel, Corps of Engineers
District Engineer

cc:
Mayor John P. McGrath
P.O. Box 369
Warwick, New York 10990

Lawska (Oper. Div.)
Caspe

FAFINSKI/NANEN
WEISS/NANEN
PAO
EA
DDE
DE

JD
DIOGUARDI/dms/91

NANEN-F

23 January 1978

Mr. George Koch
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

Reference is made to letter dated 6 January 1978, concerning our inspections of the Village of Warwick's lower dam in Warwick, New York.

The results of the joint 23 December 1977 inspection with members of your staff and my Hydraulics Section regarding downstream effects revealed a potential for damage caused by a flood wave should total dam failure occur. The analysis employed approximations as to structural dimensions and stream cross sections. It was determined that the flood wave depth would be several feet above the banks at both the first critical location (3600 feet downstream of the dam) and the most downstream location (8000 feet below the dam or the middle of the Village).

Sincerely yours,

J.A. WEISS
Chief, Engineering Division

cc:
Lawska (Oper. Div.)
Rosen (Hydraulics Sect.)
Barbero

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

FIIo
BARBERO/NANEN-F
ROSEN/NANEN-Dh
FAFINSKI/NANEN
WEISS/NANEN

DIOGUARDI/dms/91

NANEN-F
Village of Warwick Dam; I.D. No. 59

21 February 1978

Mr. George Koch
New York State Department of
Environmental Conservation
50 Wolf Road
Albany, New York 12233

Dear Mr. Koch:

Reference is made to the following:

a. Letter dated 30 December 1977 from your office to Mr. Carl Quackenbush, Supt. of Public Works, Village of Warwick regarding the downstream hazard subject dam poses, and your request to immediately lower the water surface of the reservoir.

b. Letter dated 6 January 1978 from Col. Clark H. Benn, District Engineer, New York District advising you of the definite threat caused by the seepage mentioned in this letter and calling for remedial measures to include immediate drawdown of the impoundment.

c. Letter dated 23 January 1978 from the undersigned describing the downstream effects should total failure of subject dam occur.

d. Telephone conversation between Mr. John Dioguardi of my staff and yourself on 14 February 1978 in which you indicated that the Village of Warwick had initiated the cutting of brush on the downstream slope to further observe this seepage condition but had not as of yet lowered the reservoir stage as requested in references a and b, above.

This office still considers the reported seepage in the vicinity of the right abutment to be a definite threat to the integrity of the structure requiring the immediate drawdown of the reservoir. To date no such action by the owner has been taken as indicated in reference d., above.

DIOGUARDI/dms/9111

NANEN-F
Village of Warwick Dam; I.D. No. 59

21 February 1978

It is requested that your office exercise its enforcement authority in insuring that the initial step of the recommended remedial measured outlined in reference b., be implemented immediately to obviate the possibility of dam failure with its associated downstream damage potential.

Sincerely yours,

BARBERO/NANEN-F

J.A. WEISS
Chief, Engineering Division

FAFINSKI/NANEN

WEISS/NANEN

cc
Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
77 Main Street
Warwick, New York 10990

Messrs: Lawska (Oper. Div.)
PAO ATTN: Campbell

March 3, 1978

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, New York 10990

Re: Warwick Dam #397 L.H.
Reservoir #1 (Lower Reservoir)

Dear Mr. Quackenbush:

This letter will confirm the remedial work that we discussed during our field inspection of the dam on March 2, 1978. The initial remedial work that we agreed upon involves lowering of the reservoir water surface and will be accomplished as follows:

1. On March 3, 1978 you will begin lowering the water surface by pumping water to your upper reservoir.

2. On Monday, March 6, 1978 you will continue lowering the water surface of the lower reservoir by opening the sluice gate on the 20-inch diameter drain. Gravity drainage will continue until the water surface has been lowered just below the elevation of the seep. The water surface will be lowered about 8 feet.

3. During your dewatering operation, consideration will be given to providing enough cover over the existing water pipe in the reservoir to prevent freezing. However, the water surface will be lowered at least 6 feet.

4. The water surface will be kept at the lowered elevation until permanent remedial work has been completed at the downstream portion of the earth embankment.

Field inspection at the site on March 3, 1978 indicated that there was about 12 inches of snow on the frozen ice surface. About a half-inch of water was flowing over the masonry spillway. In the vicinity of the seepage area there was less snow cover than on the rest of the earth embankment and the ground surface was frozen.

Lowering the water surface is the first step in the remedial work that is required at this dam. Later, when weather conditions are favorable for construction work, additional remedial work will be necessary. This work will include placing a stone filter blanket on the downstream slope of the earth embankment.

Please keep Ken Harmer informed of your progress in dewatering the reservoir.

Very truly yours,

George Koch
Supervisor, Dam Safety Section

cc: J. Caspe
Army Corps of Engineers

March 22, 1978

Mr. Carl Quackenbush
Supt. of Public Works
Village of Warwick
Box 369
Warwick, NY 10990

Re: Warwick Dam #397
Lower Hudson

Dear Mr. Quackenbush:

This letter will confirm our telephone conversation on the above date. You have our permission to drain the entire reservoir.

Because of the spring runoff and snow melt, you have indicated that it will take from four to six weeks before you will begin remedial work on the earth embankments. Please have your engineer submit a drawing on the planned corrective work in order that we can review your proposal.

Yours truly,

George Koch, Supervisor
Dam Safety Section

GK/jb

cc: Mr. Jerome Caspe, Army Corps of Engineers

OFFICE OF THE CORPORATION
MEETINGS HELD SECOND MONDAY OF EACH MONTH

Village of Warwick

77 MAIN STREET 10990

Orange County, N. Y.

AREA CODE 914 986—2031

March 27, 1978

Mr. George Koch
N.Y.S. Dept. of
Environmental Conservation
50 Wolf Rd.
Albany, New York 12233

Dear Mr. Koch:

After our meeting and discussion on Friday, March 3, 1978, we came to the agreement we would proceed to lower the #1 Reservoir. Following are the procedures we took and the effects of these procedures.

We began the lowering by using our 40 H.P. recirculating pump and ran it through the weekend.

3/6/78- Monday A.M.- The water had lowered 10". Just after noon that same day, we discontinued the pumping and opened a 8" gate valve to proceed with the lowering.

3/7/78- Tuesday A.M.- The water had lowered 2" more. This same day I conversed with Mr. Ken Harmer of your office and explained what was being done.

3/8/78- Wed. The water had lowered 1' more, which made the level 2' below normal.

3/9/78- Thurs.- The level had lowered 8" more and the ice was all cracked loose from the shore line and lowering with the water, which we were happy to see.

3/10/78- Fri. - Water level was down 1' more.

3/13 - Monday- After the weekend the level had been lowered 5'4". The ice was still lowering with the water.

3/14- Tuesday- We had the water level down 6' and was making adjustments with the 8" valve to try and hold this level. It rained off and on during the day.

cont'd page 2

3/15- Wed. - Water level, due to the 1.41" of rain and snow melt, came up 2'6".

3/16- Thurs.- Warm weather and continued run-off raised the level 6" more.

3/17- Fri.- Level was holding.

3/20- Monday- Changed from the 8" gate and opened the 20" gate.

3/21- Tuesday- As of today, we had the level backdown 3'6".

3/22- Wed.- I called your office and asked if you had any objections to the draining completely of this reservoir and you did not.

We found due to warm weather, we could not control any level, so this is why we decided to lower it completely.

We devoted from 3/22 till 3/24 and almost had the mission accomplished, but Saturday and Sunday we got 2.9" of rain again and the rain is still continueing today, 3/27. We are in hopes that when the rain ends and we once get the water drained, we will be able to open the 20" gate fully and it will keep the level down, without any effects of some lower area downstream.

Just as a matter of information, there was no change visually in the so called leak.

Very truly yours,

Carl Quackenbush

Carl Quackenbush
Supt. of Public Works

CQ:ms
cc: R.A. Peluso, Wehran Engineering
Jerome Caspe, Army Corps of Engineers

APPENDIX C

FLOODWAVE ANALYSIS

WARWICK Reservoir

"Dam Break Analysis"

Flood Wave Determination

Dec 1977 – Jan 1978

Refer to ASCE Paper No. 3915, dated May 1964, "Hydrology of Spillway Design," by A.F. Snyder for the method used in determining the flood wave.

Calculations by R.L. ALPERN

General steps required in order to perform the calculations of flood wave depths

1. Volume of reservoir must be determined.
2. Representative downstream sections must be chosen.
3. Compute the value of Q at the time of breach
4. Using the steps outlined in ASCE paper No. 3915, compute the downstream flood wave depths.

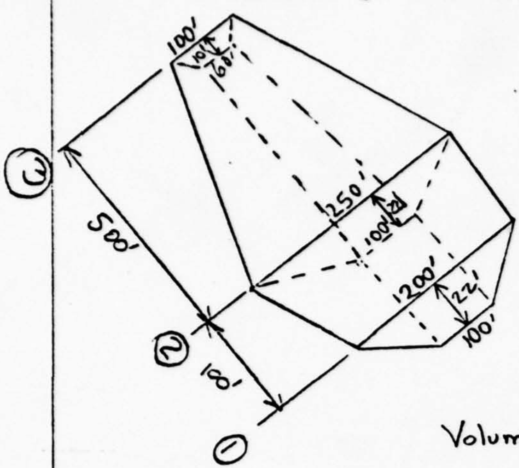
Findings

Knowing the depths at the downstream sections and the locations of the houses it was found that if the dam broke, the first set of houses at station 35+50 would have about 9 feet of water overflowing the banks. From station 35+50 to the town line there are no further houses in the flooded area. Once in the town limits, around station 60+00, the depth decreases to 5½ feet above the banks but the area is more highly populated. The depth in the middle of the town, station 80+00 decreases to 2.8 feet above the banks.

To conclude, there is a potential for damage to occur by the dam breaking.


3
Hospital
West St
Sub Sta
Ball Park
High Sch
Red Swan
Golf Course
Park
St Stephens Cem
St Stephen Cem
Warwick Cem
Warwick
Ketchum Road
Mount Peter
New Milford Road
Mountain
Warwick Reservoir
Rocky Hill
Warwick
Round Hill
Black Rock Road
Buttermilk Falls
Cascade
Lake
Conkling Rd
Bowen Road
Taylor Mountain
Taylor
Appalachian Trail
C-3

The volume of the reservoir must be found in Acre-feet



Using the average end area method.

$$A① = \tfrac{1}{2}(22)(200+100) = 3300 \text{ ft}^2$$

$$A② = \tfrac{1}{2}(22)(250+100) = 3850 \text{ ft}^2$$

$$A③ = \tfrac{1}{2}(10)(100+60) = 800 \text{ ft}^2$$

$$\text{Volume} = \left(\frac{3300+3850}{2}\right)100 + \left(\frac{3850+800}{2}\right)500$$

$$= 1{,}520{,}000 \text{ ft}^3$$

$$\text{Volume ac-ft} = \frac{1{,}520{,}000}{43560} = 34.9 \quad \text{Say } \underline{35 \text{ Ac-ft}}$$

The peak discharge at time of full breach using the W.E.S. equation is $Q_{max} = \frac{8}{27}\sqrt{g}\, K^{.28}\, W_b\, D_b^{1.5}$

where $K = \frac{W_d}{W_b} \cdot \frac{Y_o}{D_b}$

W_d = width of dam
W_b = width of breach
Y_o = overall depth of dam
D_b = depth of breach

For full breach $K = 1$

$$Q_{max} = \frac{8}{27}\sqrt{32.2}\,(200)(22)^{1.5} = 34{,}699$$

width of breach = 200'
depth = 22

Say $\underline{34{,}700 \text{ cfs}}$

The steps used to calculate the flood wave depth are as follows:

Reach A – From dam to section # 2

① Compute shape index, S_i, in hours

$S_i = \frac{12 V_b}{Q_{max}}$ V_b is reservoir storage

$S_i = \frac{\cancel{12(35)}}{\cancel{34{,}700}} = .01210$ $\quad \frac{12(1{,}520{,}000)}{34{,}700\,(3600)} = .1460$

We know the depth at the dam (Upstream section) = 22'

from the dam to section 2 is 300' in length

The average depth between the two sections must be used in the calculation: Where $D_{avg} = D_{DS} + \frac{1}{3}(D_{US} - D_{DS})$

DOWNSTREAM UPSTREAM

② In order to get D_{avg}, we must assume a downstream depth

We can try 15' as our first guess

$D_{DS} = 15'$ $D_{US} = 22'$ $D_{avg} = 15 + \frac{1}{3}(22-15) = 20.7'$

we now go to figure 2, Valley storage index, ts, and for a depth of 20.7' get a value of .125

③ We are now able to compute Ts, the index of valley storage where $T_s = L t_s$ L is in miles

$$T_s = \left(\frac{300}{5280}\right)(.125) = .0071$$

We now have the ratio $\frac{T_s}{S_i} = \frac{.0071}{\cancel{.0121}\ .1460} = \cancel{.587}\ .049$

④ We go to Fig 2., the attenuation of discharge from a breached dam. enter the ~~bottom~~ with $T_s/S_i = \cancel{.587}\ .049$

this yeilds a % of Q_{max} = ~~57%~~ 93%

Attenuated $Q_{max} = \cancel{.57}\ .93\,(34,700) = \cancel{19432}\ 32,270$

⑤ We must check to see if the attenuated Q_{max}, ~~19432~~ 32,270 can equal the maximum discharge at that section.

$$Q_{max} = \frac{8}{27}\sqrt{g}\,(W)(D_{DS})^{1.5}$$

W = width of the water surface at depth D_{DS}

$$Q_{max} = \frac{8}{27}(\sqrt{32.2})(173')(15)^{1.5} = 16900 \text{ cfs} < \cancel{19432}\ 32,270$$

⑥ Go to step ② and choose a greater depth

to increase Q_{max}. If Q_{max} was greater than the attenuated Q_{max}, we must choose a lesser depth.

Try $D_{DS} = \cancel{16.3}\ 20.5$ $\quad D_{ave} = \cancel{16.3}\ 20.5 + \frac{1}{3}(22 - \cancel{16.3}\ 20.5) = \cancel{18.2'}\ 21.0$

$W = \cancel{180}\ 205$

$\Rightarrow t_s = \cancel{.132}\ .120$

$$T_s = \left(\frac{300}{5280}\right)(\cancel{.132}\ .120) = \cancel{.0075}\ .0068$$

$$T_s/S_i = \frac{\cancel{.0075}\ .0068}{\cancel{.0131}\ .1460} = \cancel{.62}\ .047 \Rightarrow \%Q = \cancel{56\tfrac{1}{2}\%}\ 93\%$$

$$\text{Att. } Q_{max} = \cancel{.565}\ .93\,(34700) = \cancel{19605}\ 32{,}270$$

$$Q_{max} = 8/27\sqrt{32.2}\,(\cancel{180}\ 205)(\cancel{16.3}\ 20.5)^{1.5} = \cancel{19916}\ 32000 \cong \cancel{19605}\ 32{,}270$$

We can say its close enough

$\therefore$ $D_{DS} = \cancel{16.3'}\ 20.5$ $\quad Q = \cancel{19600}\ 322.70$ @ section 2

We now go to the next reach

Reach B - section 2 to 4

$D_{US} = \cancel{16.3'}\ 20.5'$ $\quad Q = \cancel{19600}\ 32270$ $\quad L = 2500'$

Try $D_{DS} = 12'$ $\quad w = 126'$

$$D_{ave} = 12 + \frac{1}{3}(\cancel{16.3}\ 20.5 - 12) = \cancel{13.43'}\ 14.8 \Rightarrow t_s = \cancel{.155}\ .14$$

$$T_s = \left(\frac{2500}{5280}\right)(\cancel{.155}\ .14) = \cancel{.0734}\ .0663$$

$$S_i = \frac{12(35)\ 1{,}520{,}000}{\cancel{19600}\ 32{,}270(3600)} = \cancel{.0214}\ .157 \qquad T_s/S_i = \cancel{3.43}\ \frac{.0663}{.157} = .423 \Rightarrow 64\%$$

$$\Rightarrow \text{Att } Q_{max} = \cancel{21\%}\ .64\,(\cancel{19600}\ 32{,}270) = \cancel{4116}\ 20{,}650 \text{ cfs}$$

$$Q_{max} = 8/27(\sqrt{32.2})(126)(12)^{1.5} = 8800 \text{ cfs} < 20{,}650\ \cancel{>> 4116}$$

N.G.

Try $D_{DS} = \overset{17.2}{\cancel{8.5}}'$ $\overset{174}{\cancel{W = 94}}'$

$$D_{ave} = \overset{17.2}{\cancel{8.5}} + \tfrac{1}{3}(\overset{20.5}{\cancel{16.3}} - \overset{17.2}{\cancel{8.5}}) = \overset{18.3}{\cancel{11.1}}$$

$$T_s = \frac{2500}{5280}(.\overset{126}{\cancel{166}}) = \cancel{.0786}\ .060$$

$$T_s/S_i = \frac{\overset{.060}{\cancel{.0786}}}{\underset{.157}{\cancel{.0214}}} = \underset{.38}{\cancel{3.67}} \Rightarrow 66\%$$

$$\text{Att } Q = \underset{.66}{\cancel{19.7\%}}(\underset{32270}{\cancel{19600}}) = \underset{21290}{\cancel{3860}}$$

$$Q_{max} = 8/27(5.67)(\underset{17.2}{\cancel{8.5}})^{1.5}(\underset{174}{\cancel{94}}) = \underset{20870}{\cancel{3913}} \cong \underset{21290}{3860}$$

Say O.K.

$\therefore$ $D_{DS} = \overset{17.2}{\cancel{8.5}}'$ $Q = \overset{21290}{\cancel{3900}}$ @ section 4

Reach C - section 4 to 5

$D_{US} = \overset{17.2}{\cancel{8.5}}'$ $Q = \overset{21290}{\cancel{3900}}$ $L = 750'$

Try $D_{DS} = \overset{10}{\cancel{6}}'$ $W = \overset{480}{270}$ $D_{ave} = \overset{12.4}{\cancel{6.83}}$ $S_i = \dfrac{12(35)}{3900} \overset{(1520000)}{} = \cancel{.11}\ .23$; $21290(3600)$

$$T_s = \frac{750}{5280}(.\overset{152}{\cancel{215}}) = \overset{.022}{\cancel{.03}}$$

$$T_s/S_i = \overset{.022}{\cancel{.03}}/\underset{.238}{\cancel{.11}} = \cancel{.28}\ .091$$

$$\text{Att } Q = \underset{.87}{\cancel{.66}}(\underset{21290}{\cancel{3900}}) = \underset{18520}{\cancel{2575}}$$

$$Q_{max} = 8/27(5.67)(\underset{10}{\cancel{6}})^{1.5}(\underset{480}{\cancel{270}}) = \underset{25570}{\cancel{6067}} \gg \underset{18520}{\cancel{2535}} \text{ N.G.}$$

Try $D_{DS} = \overset{8.8}{\cancel{4.2}}'$ $W = \overset{420}{180}$ $D_{ave} = \cancel{5.63}\ 11.6$

$$T_s = \frac{750}{5280}(.\overset{157}{\cancel{235}}) = \overset{.022}{\cancel{.033}} \quad \frac{T_s}{S_i} = \cancel{.30}\ .094$$

$$\text{Att } Q = \underset{.87}{\cancel{65\%}}(\underset{21290}{\cancel{3962}}) = \underset{18520}{\cancel{2535}}$$

$$Q_{max} = 8/27(5.67)(\underset{8.8}{\cancel{4.8}})^{1.5}(\underset{420}{\cancel{180}}) = \underset{18435}{\cancel{2600}} \approx \underset{18520}{\cancel{2535}} \text{ OK}$$

$D_{DS} = \underset{8.8}{\cancel{4.1}}'$ $Q = \underset{18500}{2550}$ @ section 5

Reach D - section 5 to 6

D us = ~~4.4~~' 8.2 Q = ~~2550~~ 18500 L = 1150

Try Dos = ~~8'~~ 4' W = ~~340~~' 510+230=740 Dave = ~~2.7~~ 5.6

$S_i = \frac{12(35)}{2550}$ 1520000 / 18500(3000) $= .16 .274$ $T_s = \left(\frac{1150}{5280}\right)(.34)$ .225 $= .07$ .05

$T_s/S_i = .45$ .18

Att Q = ~~.62(2550)~~ .78(18500) = ~~1580~~ 14430 cfs

$Q_{max} = 8/27(5.67)(2)^{1.5}(340)$ 4, 740 = ~~1010~~ cfs ≈ 1580 O.K
9950 << 14430 NG

~~Dos = 2' Q = 1580~~ @ section 6

Try 4.7' Dave = 6.06 $T_s = \frac{1150}{5280}(.216) = .047$ $T_s/S_i = .173 \Rightarrow 78\%$ Q = 1
W = 825

$Q_{max} = 8/27(5.67)(4.7)^{1.5}(825) = 14130 \approx 14430$

Reach E section 6 to 7 ∴ $\underline{D = 4.7'\ Q = 14430}$

Dos = ~~8'~~ 4.7 Q = ~~1580~~ 14430 L = 1300

Try Dos = ~~8'~~ 4' W = ~~210'~~ 400' Dave = ~~2'~~ 4.23

$S_i = \frac{35(115)}{1580}$ 1520000 / 14430(3600) $= .27 .35$

$T_s = \left(\frac{1300}{5280}\right)(.42)$ .25 $= .10$ .06 $\frac{T_s}{S_i} = \frac{.1}{.27}$ .06/.35 $= .39 .18$

Att Q_{max} = ~~.63(1580) = 1000~~
.78(14430) = 11250

$Q_{max} = 8/27(5.67)(8)^{1.5}(210)$ 4, 400 = ~~998~~ 5380 < 11250

~~Dos = 2' Q = 1000~~ @ section 7

Try 5.5' Q = 14430 W = 520 Dave = 5.23

$T_s = \left(\frac{1300}{5280}\right)(.232) = .06$ $\frac{T_s}{S_i} = .163 \Rightarrow 79\%$

Q = .79(14430) = 11400

$Q_{max} = 8/27(5.67)(5.5)^{1.5}(520) = 11280 \approx 11400$

$\underline{D = 5.5'\ Q = 11400}$

Reach (F) sections 7 to 8

$D_{us} = \cancel{8'}$ 5.5', $\cancel{Q = 1000}$ 11400 L = 2000'

Try $D_{DS} = \cancel{1'}$ 2' $w = \cancel{620'}$ 860' $D_{ave} = \cancel{1.33'}$ 3.17'

$T_S = \frac{2000}{5280}(\cancel{.49})$ .3 $= \cancel{.19}$ .11

$S_i = \frac{12(\cancel{35})}{\cancel{1000}}$ $\frac{1520,000}{11400(3600)}$ $= \cancel{.420}$ .44 $\frac{T_s}{S_i} = \cancel{.45}$ $\frac{.11}{.44} = .26$

Att $Q_{max} = \cancel{.63}(1000) = \cancel{630}$ cfs
73% (11400) = 8320

$Q_{max} = 8/27(5.67)(1)^{1.5}(620) = \cancel{1080}$ 2430

Try $D_{DS} = \cancel{.75'}$ 2.8' $W = \cancel{550'}$ W = 1070 $D_{ave} = \cancel{1.17'}$ 3.70

$T_s = \frac{2000}{5280}(\cancel{.32})$ .275 $= \cancel{.12}$ .1 $\frac{T_s}{S_i} = \cancel{.46}$ .24 $\Rightarrow \cancel{63\%}$ 74%

$Q = \cancel{630}$ cfs 8440

$q = 8/27(5.67)(\cancel{.75})^{1.5}(\cancel{550}) = \cancel{600}$ — 2.8, 1070, 8430

$D = \cancel{.8'}$ $Q = \cancel{600 \text{ cfs}}$
2.8' 8440

APPENDIX D

HYDROLOGY COMPUTATIONS

Warwick
Warwick Cem
St Stephen Cem
NEW MILFORD ROAD
Rocky Hill
BLACK ROCK ROAD
MOUNTAIN
Buttermilk Falls
Taylor Hill
Cascade Lake
VERNON
BOWEN
1" = 2000 ft

D-1

DRAINAGE AREA = 1.3 SQ. MI.

PROBABLE MAXIMUM PRECIPITATION

INDEX RAINFALL = 22 IN - 200 SQ. MI. - 24 HOURS (PLATE 1) HYDROMET NO 33

FOR 10 SQ. MI (CONSIDERED AS POINT RAINFALL)

6 HR % = 111 (PLATE 2)
12 HR % = 123
24 HR % = 133
48 HR % = 142

TRANSPOSITION FACTOR: TO OBTAIN BASIN PRECIPITATION FROM STORM PRECIP

$$1 - \frac{.3008}{(TRSDA)^{.17718}}$$

$$1 - \frac{.3008}{(1.3)^{.17718}} = 1 - \frac{.3008}{1.05} = 1 - .286 = \underline{.714}$$

UNIT HYDROGRAPH DETERMINATION

L = LONGEST LENGTH OF TRAVEL = 2.3 MI.
LCA = LENGTH TO CENTROID OF BASIN = 1.17 MI.

$$SLOPE = \frac{1480\ FT - 680\ FT}{2.3\ MI.} = \frac{800\ FT}{2.3} \approx 350\ \frac{FT}{MI.}$$

STEEP MOUNTAINOUS STREAM
USE $C_t = 2$ (AVG. APPALACHIAN STREAM) $640\ C_p = 400$

$$t_p = C_t (L\ L_{CA})^{0.3}$$
$$= 2(2.3 \times 1.17)^{0.3}$$
$$= 2(1.35) = 2.7\ HRS$$

$t_r = t_p/5.5 = 2.7/5.5 = .49$ USE t_R = UNIT DURATION = 0.5

$LAG = t_{PR} = t_p + 0.25(\underset{0}{t_R - t_r}) = 2.7\ HRS$

INCREASE LAG TIME BY 1 HOUR TO ACCOUNT FOR TRAVEL THROUGH RESERVOIRS.

$LAG = t_{PR} + 1 = 2.7 + 1 = \underline{3.7\ HOURS}$

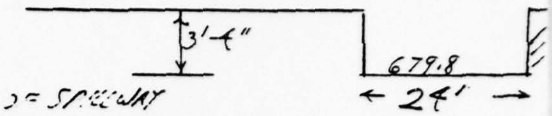
PMF PEAK = 1979 C.F.S. SEE HEC 1 OUTPUT

RECENT HYDROLOGIC WORK ON PHYSICALLY SIMILAR E. BRANCH SHELDRAKE R - D.A. = 1.87 PMF = 2730

$\left(\frac{1.87}{1.3}\right)^{0.75} = (1.438)^{0.75} = 1.313$ $\frac{2730}{1.313} = 2080$ C.F.S. ✓ GOOD CHECK

 T.S 8178

SPILLWAY RATING RELATION



$Q = CLH^{3/2}$

BROAD CRESTED WEIR $C = 2.65$ L = LENGTH OF SPILLWAY

SEE TABLE 5-3 KING'S HANDBOOK OF HYDRAULICS H = HEAD OVER SPILLWAY

$CL = 63.6$

	EL. FT. M.S.L.	HEAD	$H^{3/2}$	$CLH^{3/2}$ Q [C.F.S.]	Δ STOR	TOTAL STORAGE ACRE FT
SPILLWAY CREST	679.8	0	0		-	36.8
	680	.2	.09	5.7	.68	37.48
	681	1.2	1.315	83.6	3.4	40.88
	682	2.2	3.263	208	3.4	44.28
	683	3.2	5.724	364	3.4	47.68
	684	4.2	8.607	547	3.4	51.08

NOTE: SPILLWAY RATING ONLY APPLICABLE TO TOP OF DAM.

* STORAGE CAPACITY = 12,000,000 GAL = 1,604,278 FT³
=36.8 ACRE.FT.

7.48 GAL/FT³

43,560 SQ.FT / ACRE

APPROX. SURFACE AREA = 3.4 ACRES - "CALDWELL SURVEY"
NEWBURGH, N.Y. NOV 1870.

Q AT MAXIMUM HEAD OF 3.33 FT

$$Q = 2.65 \times 24 \times \underbrace{(3.33)^{3/2}}_{6.077} = \underline{386 \text{ C.F.S.}}$$

* - PROVIDED BY MR. CARL QUACKENBUSH, WARWICK SUPT. OF PUBLIC WORKS

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1
******************************
HEC-1 VERSION DATED JAN 1973

******************************
                    WARWICK RESERVOIR
                    RESERVOIR ROUTING OF PMF
                    24 FOOT SPILLWAY

                                         JOB SPECIFICATION
                        NQ    NHR   NMIN  IDAY   IHR  IMIN METRC  IPLT  IPRT NSTAN
                       150      0     30  0 0 0     0     0     0     0     0     0
                                               JOPER     NWT
                                                   5       0

                                MULTI-PLAN ANALYSES TO BE PERFORMED
                                     NPLAN= 1 NRTIO= 9 LRTIO= 1
             RTIOS=    .10    .20    .30    .40    .50    .60    .70    .80   1.00


          **********         **********         **********         **********         **********

                                     SUB-AREA RUNOFF COMPUTATION
                COMPUTE PMF
                         ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME
                             1       0       0       0       0       0       1

                                        HYDROGRAPH DATA
                IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                    1       1    1.30    0.00    1.30    0.00   0.000       0       1       0

                                          PRECIP DATA
                        SPFE     PMS      R6     R12     R24     R48     R72     R96
                        0.00   22.00  111.00  123.00  133.00  142.00    0.00    0.00
TRSPC COMPUTED BY THE PROGRAM IS  .713

                                           LOSS DATA
                STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                 0.00    0.00    1.00    0.00    0.00    1.00    0.00     .10    0.00    0.00

                                       UNIT HYDROGRAPH DATA
                                   TP=  3.70      CP= .63       NTA=  0

                                         RECESSION DATA
                             STRTQ=    3.00     QRCSN=     3.00     RTIOR= 1.00
APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 8.53 AND R= 6.74 INTERVALS

                UNIT HYDROGRAPH 41 END-OF-PERIOD ORDINATES, LAG=   3.70 HOURS, CP=  .63  VOL= 1.00
            6.57     24.24     48.45     75.72    103.28    125.76    139.55    140.22    136.79    120.46
          103.83     89.49     77.14     66.49     57.31     49.39     42.57     36.69     31.63     27.26
           23.50     20.25     17.46     15.05     12.97     11.18      9.63      8.30      7.16      6.17
            5.32      4.58      3.95      3.40      2.93      2.53      2.18      1.88      1.62      1.40
            1.20

                                       END-OF-PERIOD FLOW
                                  TIME    RAIN    EXCS      COMP Q
                                     1     .00    0.00        3.00
```

2	.00	0.00	3.00
3	.00	0.00	3.00
4	.00	0.00	3.00
5	.00	0.00	3.00
6	.00	0.00	3.00
7	.00	0.00	3.00
8	.00	0.00	3.00
9	.00	0.00	3.00
10	.00	0.00	3.00
11	.00	0.00	3.00
12	.00	0.00	3.00
13	.01	0.00	3.00
14	.01	0.00	3.00
15	.01	0.00	3.00
16	.01	0.00	3.00
17	.01	0.00	3.00
18	.01	0.00	3.00
19	.01	0.00	3.00
20	.01	0.00	3.00
21	.01	0.00	3.00
22	.01	0.00	3.00
23	.01	0.00	3.00
24	.01	0.00	3.00
25	.06	.01	3.06
26	.06	.01	3.27
27	.07	.02	3.78
28	.07	.02	4.74
29	.09	.04	6.35
30	.09	.04	8.79
31	.22	.17	12.99
32	.22	.17	20.38
33	.08	.03	30.70
34	.08	.03	42.52
35	.06	.01	54.55
36	.06	.01	65.22
37	.01	0.00	72.90
38	.01	0.00	76.74
39	.01	0.00	76.25
40	.01	0.00	71.65
41	.01	0.00	64.80
42	.01	0.00	57.57
43	.01	0.00	50.66
44	.01	0.00	44.30
45	.01	0.00	38.63
46	.01	0.00	33.71
47	.01	0.00	29.47
48	.01	0.00	25.82
49	.05	.00	22.68
50	.05	.00	20.02
51	.05	.00	17.79
52	.05	.00	15.95
53	.05	.00	14.44
54	.05	.00	13.23
55	.05	.00	12.26
56	.05	.00	11.47
57	.05	.00	10.82
58	.05	.00	10.27
59	.05	.00	9.79
60	.05	.00	9.38
61	.16	.11	9.71

62	.16	.11	11.94
63	.16	.11	16.75
64	.16	.11	24.44
65	.16	.11	35.04
66	.16	.11	48.01
67	.16	.11	62.45
68	.16	.11	77.38
69	.16	.11	91.56
70	.16	.11	104.03
71	.16	.11	114.78
72	.16	.11	123.90
73	.87	.82	136.45
74	.87	.82	160.67
75	1.04	.99	202.35
76	1.04	.99	265.76
77	1.31	1.26	354.06
78	1.31	1.26	467.16
79	3.31	3.26	613.84
80	3.31	3.26	809.79
81	1.22	1.17	1044.39
82	1.22	1.17	1291.38
83	.96	.91	1531.40
84	.96	.91	1742.74
85	.08	.03	1898.14
86	.08	.03	1978.70
87	.08	.03	1973.90
88	.08	.03	1885.46
89	.08	.03	1741.60
90	.08	.03	1573.69
91	.08	.03	1398.33
92	.08	.03	1225.47
93	.08	.03	1065.50
94	.08	.03	925.37
95	.08	.03	804.59
96	.08	.03	700.48
97	0.00	0.00	610.57
98	0.00	0.00	532.54
99	0.00	0.00	464.50
100	0.00	0.00	404.89
101	0.00	0.00	352.43
102	0.00	0.00	306.07
103	0.00	0.00	265.22
104	0.00	0.00	229.33
105	0.00	0.00	198.04
106	0.00	0.00	171.00
107	0.00	0.00	147.69
108	0.00	0.00	127.60
109	0.00	0.00	110.28
110	0.00	0.00	95.36
111	0.00	0.00	82.50
112	0.00	0.00	71.41
113	0.00	0.00	61.85
114	0.00	0.00	52.87
115	0.00	0.00	45.14
116	0.00	0.00	38.29
117	0.00	0.00	32.38
118	0.00	0.00	27.02
119	0.00	0.00	22.40
120	0.00	0.00	16.35
121	0.00	0.00	11.13

122	0.00	0.00	8.79
123	0.00	0.00	6.78
124	0.00	0.00	5.32
125	0.00	0.00	4.06
126	0.00	0.00	3.88
127	0.00	0.00	3.73
128	0.00	0.00	3.60
129	0.00	0.00	3.49
130	0.00	0.00	3.39
131	0.00	0.00	3.31
132	0.00	0.00	3.24
133	0.00	0.00	3.17
134	0.00	0.00	3.12
135	0.00	0.00	3.07
136	0.00	0.00	3.03
137	0.00	0.00	3.00
138	0.00	0.00	3.00
139	0.00	0.00	3.00
140	0.00	0.00	3.00
141	0.00	0.00	3.00
142	0.00	0.00	3.00
143	0.00	0.00	3.00
144	0.00	0.00	3.00
145	0.00	0.00	3.00
146	0.00	0.00	3.00
147	0.00	0.00	3.00
148	0.00	0.00	3.00
149	0.00	0.00	3.00
150	0.00	0.00	3.00
SUM	22.30	19.06	32227.00

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1978.70	1608.86	638.53	223.70	32231.00
INCHES		11.51	18.28	19.21	19.22
AC-FT		798.	1267.	1332.	1333.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
0.	0.	0.	0.	0.	0.	0.	0.	1.	1.
1.	2.	3.	4.	5.	7.	7.	8.	8.	7.
6.	6.	5.	4.	4.	3.	3.	3.	2.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	2.	2.	4.	5.	6.	8.	9.	10.
11.	12.	14.	16.	20.	27.	35.	47.	61.	81.
104.	129.	153.	174.	190.	198.	197.	189.	174.	157.
140.	123.	107.	93.	80.	70.	61.	53.	46.	40.
35.	31.	27.	23.	20.	17.	15.	13.	11.	10.
8.	7.	6.	5.	5.	4.	3.	3.	2.	2.
1.	1.	1.	1.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	197.87	160.89	63.85	22.37	3223.10
INCHES		1.15	1.83	1.92	1.92
AC-FT		80.	127.	133.	133.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
3.	4.	6.	9.	11.	13.	15.	15.	15.	14.
13.	12.	10.	9.	8.	7.	6.	5.	5.	4.
4.	3.	3.	3.	2.	2.	2.	2.	2.	2.
2.	2.	3.	5.	7.	10.	12.	15.	18.	21.
23.	25.	27.	32.	40.	53.	71.	93.	123.	162.
209.	258.	306.	349.	380.	396.	395.	377.	348.	315.
280.	245.	213.	185.	161.	140.	122.	107.	93.	81.
70.	61.	53.	46.	40.	34.	30.	26.	22.	19.
16.	14.	12.	11.	9.	8.	6.	5.	4.	3.
2.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	395.74	321.77	127.71	44.74	6446.20
INCHES		2.30	3.66	3.84	3.84
AC-FT		160.	253.	266.	267.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	2.	3.
4.	6.	9.	13.	16.	20.	22.	23.	23.	21.
19.	17.	15.	13.	12.	10.	9.	8.	7.	6.
5.	5.	4.	4.	4.	3.	3.	3.	3.	3.
3.	4.	5.	7.	11.	14.	19.	23.	27.	31.
34.	37.	41.	48.	61.	80.	106.	140.	184.	243.
313.	387.	459.	523.	569.	594.	592.	566.	522.	472.
419.	368.	320.	278.	241.	210.	183.	160.	139.	121.
106.	92.	80.	69.	59.	51.	44.	38.	33.	29.
25.	21.	19.	16.	14.	11.	10.	8.	7.	5.
3.	3.	2.	2.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	593.61	482.66	191.56	67.11	9669.30
INCHES		3.45	5.48	5.76	5.77
AC-FT		239.	389.	400.	400.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	2.	2.	3.	4.
5.	8.	12.	17.	22.	26.	29.	31.	31.	29.
26.	23.	20.	18.	15.	13.	12.	10.	9.	8.
7.	6.	6.	5.	5.	5.	4.	4.	4.	4.
4.	5.	7.	10.	14.	19.	25.	31.	37.	42.
46.	50.	55.	64.	81.	106.	142.	187.	246.	324.
418.	517.	613.	697.	759.	791.	790.	754.	697.	629.
559.	490.	426.	370.	322.	280.	244.	213.	186.	162.
141.	122.	106.	92.	79.	68.	59.	51.	44.	38.
33.	29.	25.	21.	18.	15.	13.	11.	9.	7.
4.	4.	3.	2.	2.	2.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	791.48	643.54	255.41	89.48	12892.40
INCHES		4.60	7.31	7.68	7.69
AC-FT		319.	507.	533.	533.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	3.	4.
6.	10.	15.	21.	27.	33.	36.	38.	38.	36.
32.	29.	25.	22.	19.	17.	15.	13.	11.	10.
9.	8.	7.	7.	6.	6.	5.	5.	5.	5.
5.	6.	8.	12.	18.	24.	31.	39.	46.	52.
57.	62.	68.	80.	101.	133.	177.	234.	307.	405.
522.	646.	766.	871.	949.	989.	987.	943.	871.	787.
699.	613.	533.	463.	402.	350.	305.	266.	232.	202.
176.	153.	133.	115.	99.	85.	74.	64.	55.	48.
41.	36.	31.	26.	23.	19.	16.	14.	11.	8.
6.	4.	3.	3.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	989.35	804.43	319.27	111.85	16115.50
INCHES		5.76	9.14	9.60	9.61
AC-FT		399.	634.	666.	666.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	3.	4.	5.
8.	12.	18.	26.	33.	39.	44.	46.	46.	43.
39.	35.	30.	27.	23.	20.	18.	15.	14.	12.
11.	10.	9.	8.	7.	7.	6.	6.	6.	6.
6.	7.	10.	15.	21.	29.	37.	46.	55.	62.
69.	74.	82.	96.	121.	159.	212.	280.	368.	486.
627.	775.	919.	1046.	1139.	1187.	1184.	1131.	1045.	944.
839.	735.	639.	555.	483.	420.	366.	320.	279.	243.
211.	184.	159.	138.	119.	103.	89.	77.	66.	57.
49.	43.	37.	32.	27.	23.	19.	16.	13.	10.
7.	5.	4.	3.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1187.22	965.32	383.12	134.22	19338.60
INCHES		6.91	10.97	11.53	11.53
AC-FT		479.	760.	799.	800.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	3.	3.	4.	6.
9.	14.	21.	30.	38.	46.	51.	54.	53.	50.
45.	40.	35.	31.	27.	24.	21.	18.	16.	14.
12.	11.	10.	9.	9.	8.	8.	7.	7.	7.
7.	8.	12.	17.	25.	34.	44.	54.	64.	73.
80.	87.	96.	112.	142.	186.	248.	327.	430.	567.
731.	904.	1072.	1220.	1329.	1385.	1382.	1320.	1219.	1102.
979.	858.	746.	648.	563.	490.	427.	373.	325.	283.

247.	214.	186.	161.	139.	120.	103.	89.	77.	67.
58.	50.	43.	37.	32.	27.	23.	19.	16.	11.
8.	6.	5.	4.	3.	3.	3.	3.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1385.09	1126.20	446.97	156.59	22561.70
INCHES		8.06	12.79	13.45	13.45
AC-FT		559.	887.	932.	933.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	3.	3.	4.	5.	7.
10.	16.	25.	34.	44.	52.	58.	61.	61.	57.
52.	46.	41.	35.	31.	27.	24.	21.	18.	16.
14.	13.	12.	11.	10.	9.	9.	8.	8.	8.
8.	10.	13.	20.	28.	38.	50.	62.	73.	83.
92.	99.	109.	129.	162.	213.	283.	374.	491.	648.
835.	1033.	1225.	1394.	1519.	1583.	1579.	1508.	1393.	1259.
1119.	980.	852.	740.	644.	560.	488.	426.	372.	324.
282.	245.	212.	183.	158.	137.	118.	102.	88.	76.
66.	57.	49.	42.	36.	31.	26.	22.	18.	13.
9.	7.	5.	4.	3.	3.	3.	3.	3.	3.
3.	3.	3.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1582.96	1287.09	510.82	178.96	25784.80
INCHES		9.21	14.62	15.37	15.38
AC-FT		639.	1014.	1065.	1066.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	4.	5.	6.	9.
13.	20.	31.	43.	55.	65.	73.	77.	76.	72.
65.	58.	51.	44.	39.	34.	29.	26.	23.	20.
18.	16.	14.	13.	12.	11.	11.	10.	10.	9.
10.	12.	17.	24.	35.	48.	62.	77.	92.	104.
115.	124.	136.	161.	202.	266.	354.	467.	614.	810.
1044.	1291.	1531.	1743.	1898.	1979.	1974.	1885.	1742.	1574.
1398.	1225.	1066.	925.	805.	700.	611.	533.	464.	405.
352.	306.	265.	229.	198.	171.	148.	128.	110.	95.
82.	71.	62.	53.	45.	38.	32.	27.	22.	16.
11.	9.	7.	5.	4.	4.	4.	4.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1978.70	1608.86	638.53	223.70	32231.00
INCHES		11.51	18.28	19.21	19.22
AC-FT		798.	1267.	1332.	1333.

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HYDROGRAPH ROUTING

ROUTE PMF THROUGH RESERVOIR

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME
1	1	0	0	0	0	1

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME
0.0	0.000	0.00	1	1

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA
1	0	0	0.000	0.000	0.000	37.

STORAGE=	36.80	37.48	40.88	44.28	47.68	51.08	0.00	0.00	0.00	0.00
OUTFLOW=	0.00	6.00	84.00	208.00	364.00	547.00	0.00	0.00	0.00	0.00

STATION 1, PLAN 1, RTIO 1

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	1.
1.	1.	1.	2.	3.	4.	5.	6.	7.	7.
7.	6.	6.	6.	5.	5.	4.	4.	3.	3.
3.	2.	2.	2.	2.	2.	1.	1.	1.	1.
1.	1.	1.	1.	2.	3.	4.	5.	6.	8.
10.	11.	12.	14.	17.	21.	27.	36.	48.	63.
82.	111.	137.	160.	179.	192.	197.	194.	183.	168.
151.	134.	117.	102.	89.	79.	70.	62.	54.	47.
41.	36.	31.	27.	23.	20.	17.	15.	13.	11.
10.	8.	7.	6.	6.	5.	5.	4.	4.	3.
3.	2.	2.	1.	1.	1.	1.	1.	1.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

STOR

36.81	36.82	36.82	36.83	36.83	36.83	36.83	36.83	36.83	36.83
36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83
36.83	36.83	36.83	36.83	36.83	36.83	36.84	36.84	36.85	36.86
36.88	36.91	36.97	37.04	37.14	37.24	37.35	37.44	37.50	37.53
37.52	37.50	37.47	37.43	37.38	37.33	37.27	37.22	37.18	37.14
37.10	37.07	37.04	37.01	36.99	36.97	36.96	36.95	36.94	36.93
36.92	36.92	36.93	36.97	37.02	37.10	37.20	37.32	37.45	37.57
37.65	37.71	37.76	37.83	37.94	38.13	38.41	38.80	39.30	39.96
40.79	41.63	42.33	42.96	43.48	43.83	43.97	43.88	43.60	43.19
42.73	42.25	41.79	41.37	41.01	40.66	40.28	39.91	39.58	39.28
39.02	38.78	38.58	38.40	38.24	38.10	37.98	37.88	37.79	37.71
37.64	37.59	37.54	37.49	37.45	37.39	37.33	37.27	37.21	37.15
37.09	37.04	36.99	36.95	36.92	36.90	36.88	36.87	36.86	36.85
36.85	36.85	36.84	36.84	36.84	36.84	36.84	36.84	36.84	36.83
36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83	36.83

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	196.80	160.25	63.75	22.37	3222.43
INCHES		1.15	1.82	1.92	1.92
AC-FT		80.	127.	133.	133.

STATION 1, PLAN 1, RTIO 2

0.	0.	0.	0.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	2.	3.	4.	6.	10.	12.	14.	15.	15.
14.	13.	12.	10.	9.	8.	7.	6.	6.	5.
5.	4.	4.	4.	3.	3.	3.	3.	2.	2.
2.	2.	2.	3.	4.	5.	8.	12.	15.	18.

20.	23.	25.	28.	33.	42.	55.	72.	99.	136.
179.	228.	281.	326.	343.	389.	396.	385.	362.	332.
298.	263.	230.	201.	177.	154.	134.	117.	102.	89.
79.	71.	62.	54.	47.	40.	35.	30.	26.	23.
19.	17.	15.	13.	11.	9.	8.	7.	6.	5.
4.	4.	3.	2.	2.	2.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

STOR

36.82	36.84	36.85	36.85	36.86	36.86	36.86	36.86	36.87	36.87
36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87
36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.88	36.89	36.92
36.96	37.03	37.13	37.29	37.48	37.65	37.76	37.83	37.87	37.86
37.83	37.78	37.72	37.66	37.61	37.56	37.52	37.48	37.44	37.39
37.34	37.29	37.25	37.21	37.17	37.14	37.11	37.09	37.07	37.05
37.04	37.04	37.07	37.13	37.24	37.39	37.57	37.74	37.88	38.00
38.11	38.21	38.30	38.44	38.67	39.05	39.61	40.37	41.30	42.31
43.47	44.72	45.87	46.86	47.66	48.14	48.27	48.08	47.63	46.99
46.24	45.49	44.76	44.08	43.43	42.81	42.26	41.79	41.38	41.02
40.67	40.30	39.92	39.57	39.26	38.98	38.74	38.53	38.35	38.20
38.07	37.95	37.85	37.77	37.69	37.62	37.56	37.51	37.46	37.39
37.30	37.22	37.14	37.08	37.03	36.98	36.95	36.93	36.92	36.90
36.90	36.89	36.88	36.88	36.88	36.87	36.87	36.87	36.87	36.87
36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87	36.87

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	395.60	321.14	127.64	44.70	6444.85
INCHES		2.30	3.65	3.84	3.84
AC-FT		159.	253.	266.	266.

STATION 1, PLAN 1, RTIO 3

0.	0.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	2.
2.	3.	4.	7.	12.	16.	19.	21.	22.	22.
21.	19.	17.	15.	13.	12.	10.	9.	8.	7.
6.	6.	5.	5.	5.	4.	4.	4.	4.	3.
3.	3.	4.	4.	6.	10.	14.	19.	23.	27.
31.	34.	37.	42.	50.	63.	82.	117.	156.	205.
276.	348.	426.	495.	549.	583.	593.	578.	542.	495.
443.	391.	343.	300.	261.	227.	199.	175.	153.	134.
116.	101.	88.	78.	69.	60.	52.	45.	39.	34.
29.	25.	22.	19.	16.	14.	12.	10.	8.	7.
6.	5.	4.	3.	3.	2.	2.	2.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

STOR

36.83	36.85	36.87	36.88	36.89	36.89	36.89	36.90	36.90	36.90
36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90
36.90	36.90	36.90	36.90	36.90	36.90	36.91	36.92	36.94	36.98
37.04	37.14	37.30	37.52	37.73	37.91	38.04	38.14	38.19	38.19
38.14	38.06	37.97	37.89	37.81	37.73	37.67	37.61	37.56	37.52
37.49	37.45	37.41	37.37	37.33	37.29	37.25	37.22	37.20	37.18
37.16	37.16	37.20	37.29	37.45	37.65	37.84	38.03	38.22	38.40
38.56	38.70	38.84	39.05	39.40	39.96	40.80	41.79	42.85	44.21
45.76	47.34	48.83	50.11	51.11	51.75	51.94	51.66	50.99	50.11
49.15	48.18	47.22	46.28	45.43	44.69	44.02	43.38	42.78	42.24
41.77	41.35	40.99	40.62	40.23	39.85	39.50	39.19	38.92	38.69

38.49	38.32	38.17	38.04	37.92	37.82	37.73	37.65	37.58	37.51
37.43	37.34	37.25	37.18	37.11	37.06	37.02	36.99	36.97	36.95
36.94	36.93	36.92	36.92	36.91	36.91	36.91	36.91	36.91	36.90
36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90	36.90

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	593.00	482.24	191.08	67.11	9667.28
INCHES		3.45	5.48	5.76	5.76
AC-FT		239.	380.	400.	400.

STATION 1, PLAN 1, RTIO 4

0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	2.	2.
3.	4.	6.	11.	17.	21.	25.	28.	30.	30.
28.	26.	23.	20.	18.	16.	14.	12.	11.	9.
8.	7.	6.	6.	6.	5.	5.	5.	5.	4.
4.	4.	5.	6.	9.	14.	19.	25.	31.	36.
41.	45.	50.	56.	67.	84.	118.	158.	208.	283.
369.	472.	569.	659.	732.	778.	791.	771.	723.	660.
591.	521.	455.	395.	345.	302.	263.	230.	201.	178.
155.	135.	117.	101.	88.	78.	69.	60.	52.	45.
39.	34.	29.	25.	22.	18.	16.	13.	11.	9.
7.	6.	5.	4.	3.	3.	2.	2.	2.	2.
2.	2.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.

STOR

36.84	36.87	36.89	36.90	36.91	36.92	36.93	36.93	36.93	36.93
36.93	36.93	36.93	36.94	36.94	36.94	36.94	36.94	36.94	36.94
36.94	36.94	36.94	36.94	36.94	36.94	36.95	36.96	36.99	37.04
37.12	37.25	37.47	37.72	37.94	38.15	38.32	38.45	38.52	38.51
38.44	38.34	38.23	38.11	38.00	37.90	37.82	37.74	37.68	37.62
37.57	37.53	37.50	37.47	37.44	37.41	37.38	37.35	37.32	37.29
37.27	37.28	37.33	37.46	37.63	37.83	38.06	38.30	38.55	38.79
39.01	39.19	39.38	39.66	40.12	40.88	41.82	42.90	44.28	45.91
47.77	49.69	51.50	53.17	54.51	55.37	55.62	55.24	54.35	53.18
51.90	50.60	49.37	48.26	47.26	46.33	45.48	44.75	44.09	43.45
42.83	42.28	41.79	41.36	40.98	40.61	40.22	39.83	39.48	39.18
38.92	38.69	38.49	38.32	38.16	38.02	37.90	37.80	37.70	37.61
37.51	37.42	37.34	37.26	37.18	37.12	37.07	37.04	37.02	37.00
36.98	36.97	36.96	36.96	36.95	36.95	36.94	36.94	36.94	36.94
36.94	36.94	36.94	36.94	36.94	36.94	36.94	36.94	36.94	36.94

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	791.20	643.55	255.31	89.48	12889.71
INCHES		4.61	7.31	7.68	7.69
AC-FT		319.	507.	533.	533.

STATION 1, PLAN 1, RTIO 5

0.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	2.	2.	2.	2.	2.	3.
3.	5.	9.	15.	21.	27.	32.	35.	37.	37.
35.	32.	29.	26.	22.	20.	17.	15.	13.	12.
10.	9.	8.	7.	7.	6.	6.	6.	5.	5.
5.	5.	6.	8.	13.	18.	24.	31.	36.	45.
51.	57.	62.	70.	83.	112.	149.	197.	267.	354.
469.	590.	712.	824.	915.	972.	989.	964.	904.	825.
739.	652.	569.	494.	429.	373.	328.	287.	250.	218.

192.	169.	146.	127.	110.	95.	82.	74.	65.	56.
49.	42.	36.	31.	27.	23.	20.	17.	14.	11.
8.	6.	5.	5.	4.	3.	3.	3.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

STOR

36.85	36.89	36.91	36.93	36.94	36.95	36.96	36.96	36.96	36.97
36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97
36.97	36.97	36.97	36.97	36.97	36.97	36.98	37.00	37.04	37.09
37.19	37.36	37.61	37.87	38.13	38.38	38.60	38.76	38.84	38.85
38.75	38.62	38.48	38.33	38.20	38.07	37.97	37.87	37.79	37.72
37.66	37.61	37.57	37.54	37.51	37.49	37.47	37.45	37.42	37.40
37.38	37.39	37.46	37.59	37.77	38.00	38.27	38.57	38.89	39.18
39.45	39.69	39.92	40.27	40.85	41.65	42.66	43.94	45.56	47.45
49.62	51.88	54.14	56.23	57.91	58.98	59.29	58.82	57.71	56.24
54.64	53.02	51.48	50.09	48.89	47.86	46.90	46.00	45.20	44.50
43.85	43.20	42.59	42.05	41.58	41.17	40.81	40.43	40.03	39.66
39.34	39.05	38.81	38.59	38.39	38.22	38.07	37.94	37.82	37.71
37.58	37.49	37.41	37.33	37.25	37.18	37.13	37.09	37.06	37.04
37.03	37.01	37.00	37.00	36.99	36.98	36.98	36.98	36.97	36.97
36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97	36.97

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	989.00	804.41	319.14	111.85	16112.13
INCHES		5.76	9.13	9.60	9.61
AC-FT		399.	633.	666.	666.

STATION 1, PLAN 1, RTIO 6

1.	1.	1.	1.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	3.
4.	6.	12.	18.	25.	32.	38.	42.	45.	44.
42.	39.	35.	31.	27.	24.	21.	18.	16.	14.
12.	11.	10.	9.	8.	7.	7.	7.	6.	6.
6.	6.	8.	11.	15.	21.	29.	37.	46.	54.
62.	68.	75.	84.	105.	136.	179.	241.	322.	429.
563.	708.	854.	989.	1098.	1167.	1187.	1156.	1065.	990.
886.	782.	682.	593.	515.	448.	390.	342.	300.	262.
228.	199.	175.	152.	132.	114.	98.	85.	76.	67.
58.	50.	44.	38.	32.	28.	24.	20.	17.	13.
10.	7.	6.	5.	4.	4.	3.	3.	3.	3.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

STOR

36.86	36.91	36.94	36.96	36.97	36.98	36.99	36.99	37.00	37.00
37.00	37.00	37.00	37.00	37.00	37.00	37.00	37.00	37.00	37.00
37.00	37.00	37.00	37.00	37.00	37.01	37.02	37.04	37.08	37.15
37.27	37.48	37.74	38.02	38.32	38.62	38.88	39.07	39.17	39.16
39.06	38.90	38.73	38.56	38.39	38.25	38.12	38.00	37.91	37.82
37.75	37.69	37.64	37.60	37.57	37.54	37.52	37.50	37.49	37.48
37.47	37.49	37.56	37.69	37.89	38.15	38.48	38.85	39.22	39.58
39.90	40.18	40.47	40.88	41.47	42.29	43.48	44.99	46.77	48.69
51.38	54.07	56.79	59.29	61.31	62.59	62.97	62.40	61.07	59.31
57.39	55.44	53.59	51.93	50.49	49.24	48.17	47.20	46.29	45.45
44.72	44.05	43.38	42.75	42.18	41.69	41.27	40.90	40.53	40.13
39.75	39.42	39.12	38.86	38.63	38.42	38.24	38.08	37.94	37.80
37.66	37.54	37.46	37.38	37.30	37.23	37.18	37.14	37.11	37.09
37.07	37.05	37.04	37.03	37.03	37.02	37.02	37.01	37.01	37.01

37.01	37.01	37.01	37.00	37.00	37.00	37.00	37.00	37.00	37.00

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1186.80	965.29	382.97	134.22	19334.56
INCHES		6.91	10.96	11.52	11.53
AC-FT		479.	760.	799.	799.

STATION 1, PLAN 1, RTIO 7

1.	1.	1.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	3.	4.
5.	8.	14.	22.	30.	38.	44.	50.	52.	52.
49.	45.	40.	36.	31.	28.	24.	21.	18.	16.
14.	13.	11.	10.	9.	9.	8.	8.	7.	7.
7.	7.	9.	13.	18.	25.	34.	44.	54.	63.
72.	79.	88.	102.	123.	158.	209.	285.	377.	505.
657.	826.	997.	1154.	1281.	1361.	1385.	1349.	1265.	1155.
1034.	912.	796.	692.	601.	523.	455.	397.	346.	305.
266.	231.	202.	177.	153.	133.	114.	99.	85.	76.
67.	59.	51.	44.	38.	32.	27.	23.	19.	16.
12.	9.	7.	6.	5.	4.	4.	3.	3.	3.
3.	3.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

STOR

36.87	36.92	36.96	36.98	37.00	37.01	37.02	37.03	37.03	37.03
37.03	37.04	37.04	37.04	37.04	37.04	37.04	37.04	37.04	37.04
37.04	37.04	37.04	37.04	37.04	37.04	37.05	37.08	37.13	37.21
37.35	37.57	37.84	38.16	38.51	38.85	39.16	39.38	39.49	39.48
39.36	39.18	38.98	38.78	38.59	38.42	38.27	38.13	38.02	37.92
37.84	37.77	37.71	37.67	37.63	37.60	37.57	37.55	37.53	37.52
37.51	37.54	37.61	37.76	38.00	38.31	38.69	39.12	39.55	39.97
40.35	40.68	40.99	41.37	41.96	42.91	44.30	45.97	47.92	50.29
53.12	56.26	59.43	62.36	64.71	66.20	66.64	65.98	64.42	62.37
60.13	57.86	55.71	53.77	52.08	50.63	49.38	48.30	47.33	46.40
45.55	44.79	44.11	43.43	42.78	42.21	41.72	41.29	40.92	40.55
40.15	39.78	39.44	39.14	38.86	38.62	38.41	38.23	38.06	37.90
37.73	37.60	37.51	37.43	37.35	37.28	37.22	37.18	37.15	37.13
37.11	37.09	37.08	37.07	37.06	37.06	37.05	37.05	37.04	37.04
37.04	37.04	37.04	37.04	37.04	37.04	37.04	37.04	37.04	37.04

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1384.60	1126.17	446.80	156.59	22556.96
INCHES		8.06	12.79	13.45	13.45
AC-FT		559.	887.	932.	933.

STATION 1, PLAN 1, RTIO 8

1.	1.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	3.	3.	3.	4.
6.	10.	17.	25.	34.	43.	51.	57.	60.	59.
56.	52.	46.	41.	36.	31.	27.	24.	21.	18.
16.	15.	13.	12.	11.	10.	9.	9.	8.	8.
8.	8.	10.	14.	20.	29.	39.	50.	61.	72.
82.	93.	103.	117.	141.	181.	243.	326.	435.	577.
750.	944.	1139.	1319.	1464.	1555.	1562.	1542.	1446.	1320.
1182.	1042.	910.	790.	687.	598.	521.	454.	396.	347.
304.	264.	229.	200.	175.	151.	131.	113.	98.	84.
76.	67.	58.	50.	43.	37.	31.	26.	22.	18.
13.	10.	8.	6.	5.	5.	4.	4.	3.	3.

3.	3.	3.	3.	3.	3.	3.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.

STOR

36.88	36.94	36.98	37.01	37.03	37.04	37.05	37.06	37.06	37.07
37.07	37.07	37.07	37.07	37.07	37.07	37.07	37.07	37.07	37.07
37.07	37.07	37.07	37.07	37.07	37.08	37.09	37.12	37.18	37.27
37.43	37.66	37.95	38.30	38.69	39.09	39.43	39.69	39.82	39.80
39.67	39.47	39.23	39.00	38.79	38.59	38.42	38.27	38.14	38.02
37.93	37.85	37.78	37.73	37.69	37.65	37.62	37.60	37.58	37.56
37.56	37.58	37.67	37.84	38.11	38.47	38.90	39.39	39.89	40.36
40.79	41.12	41.39	41.77	42.45	43.53	45.03	46.86	49.00	51.63
54.86	58.46	62.08	65.42	68.11	69.81	70.32	69.56	67.78	65.44
62.88	60.29	57.82	55.60	53.68	52.02	50.59	49.35	48.27	47.30
46.37	45.51	44.75	44.05	43.38	42.73	42.16	41.68	41.25	40.89
40.52	40.12	39.75	39.41	39.10	38.83	38.58	38.37	38.18	38.00
37.80	37.65	37.55	37.47	37.39	37.32	37.27	37.23	37.19	37.17
37.15	37.13	37.12	37.11	37.10	37.09	37.09	37.08	37.08	37.08
37.08	37.07	37.07	37.07	37.07	37.07	37.07	37.07	37.07	37.07

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1582.41	1287.05	510.63	178.96	25779.41
INCHES		9.21	14.62	15.37	15.37
AC-FT		639.	1013.	1065.	1066.

STATION 1, PLAN 1, RTIO 9

1.	2.	2.	2.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	4.	4.	5.
8.	14.	21.	31.	42.	54.	64.	71.	74.	74.
70.	64.	58.	51.	45.	39.	34.	30.	26.	23.
20.	18.	16.	15.	13.	12.	12.	11.	10.	10.
10.	10.	13.	18.	25.	36.	48.	62.	77.	92.
107.	118.	128.	146.	176.	228.	308.	411.	547.	721.
938.	1160.	1424.	1648.	1830.	1944.	1978.	1927.	1808.	1650.
1477.	1303.	1137.	988.	858.	747.	651.	567.	495.	432.
376.	330.	287.	248.	215.	188.	163.	141.	122.	106.
91.	80.	71.	62.	54.	46.	39.	33.	28.	22.
17.	12.	9.	7.	6.	5.	5.	4.	4.	4.
4.	4.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	3.	3.

STOR

36.90	36.98	37.03	37.06	37.09	37.10	37.11	37.12	37.13	37.13
37.13	37.14	37.14	37.14	37.14	37.14	37.14	37.14	37.14	37.14
37.14	37.14	37.14	37.14	37.14	37.15	37.16	37.20	37.27	37.39
37.57	37.81	38.15	38.58	39.06	39.56	39.99	40.30	40.46	40.45
40.28	40.03	39.74	39.45	39.18	38.93	38.72	38.53	38.37	38.23
38.11	38.01	37.93	37.86	37.80	37.76	37.72	37.69	37.67	37.65
37.64	37.67	37.78	38.00	38.33	38.78	39.32	39.93	40.55	41.11
41.51	41.80	42.10	42.57	43.42	44.72	46.45	48.56	51.09	54.30
58.35	62.84	67.37	71.54	74.91	77.04	77.67	76.72	74.50	71.57
68.36	65.15	62.04	59.27	56.87	54.79	53.01	51.46	50.11	48.93
47.90	46.93	46.00	45.16	44.42	43.73	43.06	42.45	41.92	41.47
41.08	40.72	40.33	39.94	39.56	39.22	38.92	38.66	38.43	38.19
37.95	37.76	37.63	37.53	37.46	37.39	37.34	37.30	37.27	37.25
37.23	37.21	37.19	37.18	37.17	37.16	37.16	37.15	37.15	37.15
37.14	37.14	37.14	37.14	37.14	37.14	37.14	37.14	37.14	37.14

PEAK 6-HOUR 24-HOUR 72-HOUR TOTAL VOLUME

CFS	1978.01	1608.82	638.29	223.70	32224.26
INCHES		11.51	18.27	19.21	19.22
AC-FT		798.	1267.	1332.	1332.

*********** *********** *********** *********** ***********

PEAK FLOW SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS

			RATIOS APPLIED TO FLOWS								
OPERATION	STATION	PLAN	.10	.20	.30	.40	.50	.60	.70	.80	1.00
							S.P.F.				P.M.F.
HYDROGRAPH AT	1	1	198.	396.	594.	791.	989.	1187.	1385.	1583.	1979.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.
ROUTED TO	1	1	197.	396.	593.	791.	989.	1187.	1385.	1582.	1978.
		2	0.	0.	0.	0.	0.	0.	0.	0.	0.

APPENDIX E

CHECKLISTS

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION
PHASE I

NAME OF DAM Lower Warwick Res. Dam

ID # 59

ITEM	REMARKS
AS-BUILT DRAWINGS	N/A
REGIONAL VICINITY MAP	USGS
CONSTRUCTION HISTORY	Built Approx. 1887
TYPICAL SECTIONS OF DAM	Yes - No Zoning or Embankment Materials
OUTLETS - PLAN	20" C.I. Pipe -
- DETAILS	Gate val. U/S of dam
-CONSTRAINTS	
-DISCHARGE RATINGS	
RAINFALL/RESERVOIR RECORDS	

E-1

ITEM	REMARKS
DESIGN REPORTS	None
GEOLOGY REPORTS	None
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	N/A
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	N/A
POST-CONSTRUCTION SURVEYS OF DAM	1978 Wehran Eng.
BORROW SOURCES.	N/A - 1978 Rehab. - Bank Run from Village Pit

ITEM	REMARKS
MONITORING SYSTEMS	
MODIFICATIONS	1978 Wehran Engrg
HIGH POOL RECORDS	
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	1978 Wehran Eng
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	None
MAINTENANCE OPERATION RECORDS	N/A

ITEM	REMARKS
SPILLWAY PLAN	
SECTIONS	N/A OTHER THAN ELEV.
DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS	N/A

CHECK LIST
HYDROLOGIC AND HYDRAULIC
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: AVERAGE MODERATELY STEEP

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 679.8 FT. MSL

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N/A

ELEVATION MAXIMUM DESIGN POOL: N/A

ELEVATION TOP DAM: 683.1

CREST:

- a. Elevation 679.8 FT. MSL
- b. Type BROAD CRESTED
- c. Width 3
- d. Length 24 FT
- e. Location Spillover WEST ABUT.
- f. Number and Type of Gates NONE

OUTLET WORKS:

- a. Type 20" C.I.
- b. Location WEST OF CENTER LINE
- c. Entrance inverts 659.6 FT. MSL
- d. Exit inverts 651.12
- e. Emergency draindown facilities 20" PIPE

HYDROMETEOROLOGICAL GAGES:

- a. Type NONE
- b. Location
- c. Records

MAXIMUM NON-DAMAGING DISCHARGE: (SPILLWAY CAP) 386 CFS

Check List
Visual Inspection
Phase 1

Name Dam Warwick   County Orange   State NY   ID # 59

Type of Dam Earth   Hazard Category 2 on Inventory. Should be 1

Date(s) Inspection 9 Aug 197?   Weather Fair   Temperature 85°F

Pool Elevation at Time of Inspection 680.05 M.S.L.   Tailwater at Time of Inspection ______ M.S.L.

Inspection Personnel:

J. Caspe

T. Smythe

Caspe   Recorder

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ANY NOTICEABLE SEEPAGE		
TRUCTURE TO BUTMENT/EMBANKMENT, UNCTIONS		
RAINS		
TER PASSAGES		
UNDATION		

CONCRETE/MASONRY DAMS

VISUAL EXAMINATION OF	OBERSVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		
STAFF GAGE OF RECORDER;		

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIO
SURFACE CRACKS	NONE	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	NONE	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	NO EVIDENCE OF THRU SEEPAGE SOME MINOR SURFACE EROSION ON NEW D/S EMBANKMENT SLOPES	
VERTICAL AND HORIZONTAL ALINEMENT OF THE CREST	GOOD	
RIPRAP FAILURES	NO RIP RAP	

EMBANKMENT

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
UNCTION OF EMBANKMENT ND ABUTMENT, SPILLWAY ND DAM	No Evidence of Distress	
NY NOTICEABLE SEEPAGE	None	
TAFF GAGE AND RECORDER	None	
RAINS		

UNGATED SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Minor Surface Scaling No Structural Cracking	
APPROACH CHANNEL	Concrete Sill Under Water	
DISCHARGE CHANNEL	Rock Cut	
BRIDGE AND PIERS	Wood Bridge Missing Rungs –	Does Not Affect Safety of Dam

GATED SPILLWAY

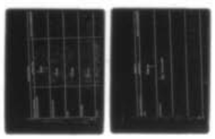
ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
ONCRETE SILL		
APPROACH CHANNEL		
DISCHARGE CHANNEL		
BRIDGE AND PIERS		
GATES AND OPERATION EQUIPMENT		

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIO
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	N/A	
INTAKE STRUCTURE	NOT IN USE ANY MORE 24" C.I. PIPE THRU EMBANKMENT	MANUAL VALVE P.T OPERATIONAL
OUTLET STRUCTURE	N/A	
OUTLET CHANNEL	BED ROCK	
EMERGENCY GATE	N/A	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDA
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	TREE LIMBS	
SLOPES	STABLE - ROCK	
APPROXIMATE NO. OF HOMES AND POPULATION	APPROX 3600' D/S HOUSING DEVELOPMENT 8000' D/S CENTER OF VILLAGE OF WARWICK	



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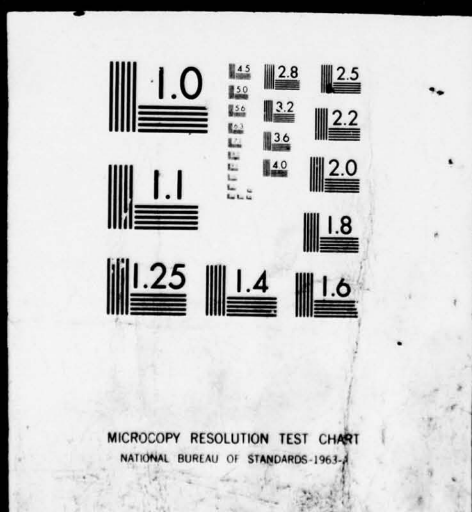

INSTRUMENTATION

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATION
MONUMENTATION/SURVEYS	None	
OBSERVATION WELLS	None	
WEIRS	None	
PIEZOMETERS	None	
OTHER		

RESERVOIR

ISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LOPES	STABLE	
EDIMENTATION	NOT INVESTIGATED	